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CIVIL ENGINEERING.

Translated for the Journal of the Franklin Institute.

Theoretical Formulæ for the Movement of Air in Conduit Pipes. By Gen. A. MORIN, Academy of Sciences of Paris.

IN the work upon the Steam Engine which I had the honor to present to the Academy of Sciences in 1843, I had, among other questions, treated of the movement of steam from its issuing from the boiler until its entry into the cylinder. The application of the principle of living-forces and of the rules admitted to estimate the influence of the various circumstances which the circulation of this fluid presents, to a steam engine established in the shops of the *Messageries Royale*, had moreover shown me that the results of experiment were as conformable to those of theory as one could hope for in such investigations.

As I have been induced for some time past to occupy myself with questions which are connected with the movement of elastic fluids, and especially with that of air in ventilation apparatus, I thought that whilst it was indispensable to consult experiment, it was also necessary to ask of Science, rules which might guide us in the establishment of the apparatus. I was thus led to seek for the means of establishing the formulæ for the movement of air, applying to it the principle of living-forces or of the transmission of work, according to the rules indicated by Borda, and developed by M. Poncelet in his lectures at the School at Metz.

In this work, of which I propose to give to the Academy an analysis as succinct as possible, I begin by establishing the equation of the transmission of work, taking into consideration all the losses of living-force which can be produced in the air-conduits, and of the work consumed by the passive resistances.

This question has also been treated, partially at least, by a distinguished physicist whose still recent loss, Science regrets; but beside the fact that he did not complete the solution, he committed errors in the mechanical part of the question which it is important to rectify.

In the movement of the air through the pipes of the apparatus for warming and ventilation, where recourse has not been had to machines, the motive force is due only to the difference of the pressures, densities, or temperatures, and after finding the expression for them we must equate it to all the losses of living-forces which may be produced added to the work consumed by the resistance of the walls.

The losses of living-force are or may be very numerous, but we have rules for calculating them. It will be sufficient if I enumerate them. They are produced—

1st. At the entrance of the pipe in consequence of the contraction there, which is scarcely ever avoided. The expression is (as is known) of the form $\text{M}\left(\frac{1}{m}-1\right)^2 \text{U}^2$; M being the mass of air passing in 1 sec.; U the mean velocity in the pipe; m the co-efficient of contraction at the mouth.*

2d. At leaving the chimney or pipe, the air possesses a living-force which is not utilized, and which is greater in proportion as the orifice is more contracted.

3d. When the orifice of entry of the air into the pipe, has a section notably smaller than that of the pipe, the loss of living-force after passing this orifice may be very great. This happens especially when the air has to pass through a grate loaded with fuel.

4th. Every bend also produces a loss of force, and when there are several the loss may be sensible.

5th. The meeting of two currents often produces an analogous effect.

6th. Every enlargement of a pipe has also an influence of the same kind.

7th. As to the resistance of the walls, we know how to express the work which it absorbs; but up to this time the constant co-efficient which enters into this expression has only been determined by the experiments of Girard and of d'Aubuisson, made on pipes of polished sheet iron, and a value has been admitted for this co-efficient $\beta = 0{\cdot}0031$.

The experiments of the late M. Darcy on the movement of water in conduit-pipes having shown that the presence of the slightest de-

* This is the proper place to remark that Mr. Peclet in the formula given in his 3d edition, p. 114, supposes that this loss is expressed by $\text{M}.\frac{1}{m^2}\text{V}^2$, which leads to a serious error, and is reproduced in the most of his other formulæ.

posits, such as would diminish the polish of the surface, might triple the value of the analogous co-efficient in water, it is natural to think that the wrinkled surface of pipes of masonry (such as the air flows through in such apparatus), such as are now in question, may have an analogous influence. This is also sufficiently shown by the experiments of M. Peclet.

Taking into consideration all the circumstances of the movement of air, we find for the expression for the volume of air at the temperature of the chimney, which is discharged in one second, by a pipe or by a chimney, under the sole action of the difference of densities, a formula of the form

$$Q = AU = A\sqrt{\frac{2g\left(\frac{D-d}{d}\right)H \text{ or } 2ga\frac{(t-T)H}{1+aT}}{\left(\frac{A}{m'A_1}\right)^2+\left(\frac{1}{m}-1\right)^2+\left(\frac{A}{m'A'}-1\right)^2+\left(\frac{1}{m''}-1\right)^2+\left(1-\frac{A}{O}\right)^2+\frac{2SL\beta}{A}}}$$

Where Q represents the volume of air which escapes in 1 second; in cubic metres.

A	the mean section of the chimney.
U	the mean velocity in that section.
D and T	the density and temperature of the external air.
d and t	" " of the air in the chimney.
a	0·003665 the co-efficient of dilatation of air.
m	the co-efficient of contraction at the entrance of the chimney.
A_1 and m_1	the area and co-efficient of contraction for the exit from the chimney.
A' and m'	the area and co-efficient of contraction for an orifice of entrance differing from the section of the chimney.
m''	0·65 a co-efficient of contraction for an elbow.
O	the area of a passage greater than that of the chimney.
S and L	the perimeter and length of the pipe whose section is A.
β	the co-efficient of friction of the air against the walls.

Many of the terms in this formula may be repeated a number of times, others may not exist; according to the arrangement of the pipes.

In seeking to appreciate the influence of the various terms which enter into this expression, we recognise at once, as was evident *à priori*, that the volume of air Q, at the temperature of the chimney, which can pass through the pipe is nearly directly proportional to its transverse section, and as we may almost always control this section, there results a great facility for obtaining such results as we may desire.

As to the numerator of the fraction which is under the radical, it

shows that the velocity in a pipe increases only with its square root, and consequently less rapidly in proportion as it is greater.

This numerator having for its value

$$2g\left(\frac{D-d}{d}\right)H = 2ga\frac{(t-T)H}{1+aT}$$

it is seen at once that it increases; 1st, proportionally to the square root of the height of the chimney (or orifice of discharge) above the entrance opening, which was known before: 2d, proportionally to the factor $\frac{t-T}{1+aT}$, and that the height H of the chimney being once determined, if we wish to make the velocity of the air nearly constant, this factor must have the same value whatever be the external temperature T.

In the applications to ventilation where the temperatures of the external air are most frequently such that the term $1+aT$ differs little from unity,* it will be seen that we may always secure the same velocity and consequently the discharge of the same volume of air at the temperature of the chimney, by maintaining the excess of the temperature of the chimney over that of the external air, constant.

Whence results this practical rule, very simple, but only true within certain limits: "To obtain in a given and established system of ventilation by draft, the discharge of the same volume of air whatever may be the variations of the external temperature, it is necessary and it is sufficient to regulate the working of the heating apparatus, so that the excess of the temperature of the air in the chimney over that of the external air may be constant."

This rule is in accordance with a great number of experiments.

As to the denominator, all whose terms are positive, it may in certain arrangements of the pipes acquire a value sufficient to diminish materially the velocity of discharge.

By introducing into it numerical values and by supposing between the sections of the passages ratios which are frequently met with in practice, I have shown that in quite common circumstances the velocity of discharge may be reduced to one-fourth of the value which it would have if these causes of loss were suppressed, and that often it does not exceed one-tenth of this value.

I have just said that the practical rule which I announced was only true within certain limits: in fact, the volume of air discharged by the chimneys to which it applies, is not that which it is important to render constant in ventilating apparatus. This volume is that of the warm air which is discharged by the chimney, while the volume of air which assures the ventilation of inhabited buildings is that which is introduced to replace the vitiated air discharged.

* It is necessary to notice here a fault of considerable gravity in the formula of M. Peclet. This physicist in his 3d edition, vol. ii. p. 37, introduced into the numerator the factor $\frac{t-T}{1+at}$ in place of $\frac{t-T}{1+aT}$, which if applied to chimneys in which the air is strongly heated, might lead to important errors.

Now, it is easy to see that this latter volume, which is at a temperature T lower than that of the chimney (t), is less than the first in the ratio, $\frac{1+a\,\mathrm{T}}{1+a\,t}$, whence it results that its expression is

$$\mathrm{Q}' = \mathrm{A}\sqrt{\frac{1+a\,\mathrm{T}}{\mathrm{K}}}\sqrt{2\,g\,a\,\mathrm{H}}\sqrt{\frac{t-\mathrm{T}}{(1+a\,t)^2}}$$

and that it is susceptible of a maximum corresponding to the value

$$t = \frac{1+2\,a\,\mathrm{T}}{a},$$

Which maximum is $\mathrm{Q}' = \frac{\mathrm{A}}{\mathrm{K}}\sqrt{\frac{g\,\mathrm{H}}{2}}$,

K representing the radical which forms the denominator of the preceding equation for the value (Q) of the air at the temperature t.

This maximum value for the effect of a chimney has this remarkable about it, that its value is absolute and completely independent of the disposition and arrangement of the apparatus: if the temperature of the external air is 0° Cent. this value is 272°; if T=10°, t=282°: and these values are nearly those of the mean temperatures which are established in the chimneys of well constructed steam engines.

Influence of the Section of the Chimney on the Economy of Fuel.—The size of the transverse section of the chimney has not only a favorable influence on the velocity of discharge, but it also has a much more direct and preponderant one on the volume of the air discharged, and this has a notable influence on the economy.

In fact, as the volume of air evacuated from the rooms to be ventilated, increases only with the square-root of the factor $\frac{t-\mathrm{T}}{(1+a\,t)^2}$, whilst it increases in proportion to the mean transverse section of the chimney, it is easy to see that whilst an increase of temperature from 20° to 80° augments the volume of air at 10° drawn in only as 1 to 2·19, we should obtain nearly the same increase by doubling the section of the chimney. But this last method would be only an expense to be submitted to once; whilst the increase of the temperature of the air from 10° to 20° and from 10° to 80°, would increase the expenditure of fuel in the ratio of 10 to 70, whilst the effect of ventilation would increase only as 1 to 2·19.

There is therefore a great advantage in employing chimneys of large section and moderate temperatures to obtain the effects of ventilation by draft.

It must however be remembered, that the stability of the ventilation requires that the velocity in the chimneys of discharge shall not be less than 2 m. or 2·5 m.

Application of the Theoretical Formulæ to different cases; and comparison of their results with those of observation.—After having explained the rules to which theory leads,—passing to the application of the general considerations to several peculiar cases, I examine in

the first place that of a straight chimney under ordinary conditions, and I come directly for this simple case to the following formula:

$$U = 0{\cdot}9544 \sqrt{\frac{D\,H\,(t-T)}{L+16{\cdot}11\,D}},^{*}$$

which expresses the mean velocity in the vertical pipe of a chimney in functions of its dimensions and of the difference of the interior and exterior temperatures.

Now in seeking to modify, by the discussion of a great number of observations, a formula given by M. Peclet in the 1st edition of his *Traité de la Chaleur*, the inaccuracy of which this physicist had since recognised, a skilful practical man, M. Guerin, engineer for the house L. Duvoir-Leblanc, reached the following rule:

$$U = \sqrt{\frac{D\,H\,(t-T)}{L+16\,D}};$$

which is, so to speak, identical with that to which the principle of living-forces leads.

Comparison of the different arrangements employed to produce the draft of the vitiated air.—Among the different means of determining the movement of the air in draft-chimneys, there are two which have been applied in many large establishments, sanitary and others.

In the one, the furnace which excites the draft is established in the upper part of the building; this has received with more or less correctness, the name of *draft from above.*

In the other, the furnace is established in the cellar of the building, and all the vitiated air to be extracted is brought there by descending pipes; it may be called, *draft from below.*

Between these extremes there was a third which it was desirable to study, and which consists in placing the furnace on the same level with the air to be extracted; this, in imitation of the names which we have mentioned, may be called *draft from the level.* This system has been employed in the Polytechnic School, and has just been introduced into the offices of the Northern Railroad.

By applying to these three systems the considerations which we have mentioned, and supposing them of equal proportions in all other respects, we are able to calculate the velocities of the discharge of the air from the different stories of the same building; and according to the data which we have admitted for the three cases, we have been able to form the following table, which permits the appreciation of the effect of these three systems.

	Velocity of the discharge of the air.		
	Draft from below.	Draft from the level.	Draft from above.
Basement, .	2·593 metres.	2·684 metres.	2·251 metres.
First story, .	2·508 "	2·450 "	2·144 "
Second story, .	2·431 "	2·119 "	1·994 "

* In the formula of Peclet, and consequently probably here, L expresses the length of the flue which opens into the chimney below, the diameter of which is supposed equal to that of the chimney. D is the length of the side of the chimney supposed square, t and T, as before. ED. F. I. J.

This table shows that, of the three systems of draft indicated, according to the hypotheses, and with the same numerical data nearly approximating to the circumstances which may present themselves in practice, that in which the air drawn out is heated on the level of each story, will cause, for the same expenditure of heat, a rather greater velocity for the basement, about the same for the first story, and a little less for the second story, than that in which the draft is produced from below. As to the system in which the furnace is placed above the stories to be ventilated, it will cause, as was to be expected, velocities in all the cases rather less than the other two systems.

The system of *draft from the level* appears therefore to be the most advantageous of the three: its superiority and that of the draft from below over that of the draft from above is to be entirely attributed to the fact that in the two first systems, the heights of the discharge chimneys permit more advantage to be taken of the specific levity given to the air: but it must not be forgotten that, as the walls of the chimney cool the air which passes through them, the velocity may thus be diminished and the advantage of this arrangement somewhat reduced.

However this may be, it appears to me to result from this discussion that the system of draft from the level ought to be preferred to the two other systems; its introduction presents no difficulties of construction, and according to the examination of the proposals for the offices of the Northern Railroad, it appears to be both more economical in cost of construction and of daily expenditure: the great height of the chimneys must also give great stability to the effects.

Introduction of the External Air by the Heating Apparatus.—By examining in a theoretical point of view the conditions of the introduction of air by hot-water apparatus, into the wards of the Hospital Lariboisière, and introducing the data from observation into the formulæ obtained, we obtain the following results:

The temperature of the air furnished by the stoves being respectively

32°, 26°, 22°, 21° (Cent.);

the values of the velocity of inflow of the air into the wards were found

by the formulæ, 1·29 met.; 1·21 met.; 1·18 met.; 1·17 met. per second.
by experiment, 1·14 " ; 1·04 " ; 1·13 " ; 1·15 " "

If we take into consideration the uncertainty which may exist as to the dimensions and especially the obstacles sometimes inevitable, such as mere spider-webs, which are too often found in the conduits and stove-pipes, it will be without doubt admitted, that the accordance of the formula with experiment is at least sufficiently satisfactory to allow of its being taken, with some latitude, for an approximative rule for the arrangement and proportions to the apparatus in analogous cases.

The formula which is applicable to the cases just mentioned shows this remarkable circumstance, that the temperature of the air which traverses the stoves, which, it may be remarked, is very moderate, has much less influence over the velocity of that air during heating than

the air of the ward at its normal temperature. This is the consequence of the slight height given to the stoves.

This result shows the necessity of giving to the stoves as great a height as possible.

As to the introduction of the air in summer, the same formula shows the insufficiency of the orifices offered by the stoves, and I recall in my Memoir the easy means of remedying this, which I had already noted on other occasions.

Application to the Apparatus for Ventilation by Draft of the Hospital Lariboisière.—The work which I present to the Academy contains, moreover, a complete application of the principles exposed, to the effects of ventilation which are produced in the wings of the Hospital Lariboisière which are ventilated by draft. It is known that each one of these wings has three stories, each composed of a ward containing thirty-two beds, and a small chamber of two beds. The vitiated air is drawn off from the wards of each story by nineteen discharge-chimneys, which unite under the roof at the base of a general discharge-chimney, in which is the reservoir of hot water intended to stimulate and regulate the draft.

Taking into consideration all the circumstances of the movement of the air in these complex circulations, the mean velocity of discharge in the general chimney may be calculated, and we thus obtain a formula into which, introducing the data of observation of five experiments made, the first two in the winter season, when the temperatures of the external air were —5° and —2° (Cent.), and the last three in summer, at an external temperature of 18·3° (Cent.), then comparing the results of calculation with those of direct experiment, we reach the following results :—

	Temperatures of the air.			Velocity in the chimney.	
	External.	Wards.	Chimney.	Formula.	Experiment.
11th January, 1861,	—5° Cent.	15° Cent.	19° Cent.	1·465 met.	1·39 met.
20th " "	—2	15	18	1·334 "	1·24 "
31st August, 1861,	18·3	21·5	38·1	0·949 "	0·95 "
		22	41·2	1·051 "	0·94 "
		22	40·9	1·041 "	1·07 "

The examination of these results shows that, even for cases as complex as those here considered, the principle of living-forces or work, leads to formulæ which accord as well with practice as could be expected in such applications.

This comparison also shows the enormous influence exerted by the losses of force and resistance of the walls, upon the effects which the difference of temperatures would naturally produce. These two causes conjoined reduce the velocity of discharge in the chimneys to about 0·33 of what it would have been if they could have been avoided; which shows the importance of all the arrangements which diminish these effects which, however, cannot be entirely got rid of.

Finally, the application of which we have discussed the results, shows that in the denominator of the fraction placed under the radical of the expression for the velocity, the term which depends on the loss of living-force enters for 0·864 of its value, and that arising from the resistance of the walls to 0·136 only; which shows the importance of avoiding complicated circulations.

Application of the Discussion of the Experiments made at the CONSERVATOIRE DES ARTS ET METIERS.—Besides the application of the theoretic formulæ to the practical apparatus for the circulation of air, others were made for the discussion of the direct experiments which M. Tresca and myself had executed during an investigation into the chimneys of steam engines.

These experiments, which we propose to resume immediately, were tried under three different conditions:—

1st. Upon a zinc chimney of 0·24 m. diameter and 11 metres high, entirely open at its two extremities, and under which were successively lighted one, two, three, and four gas-lights.

2d. Upon the same chimney surmounted by an elongated conical ajutage, of which the upper opening was made to vary by cutting it off, and giving to it successively the diameters 0·10 m.; 0·14; 0·18; 0·21.

3d. Upon a cylindrical chimney of 0·25 m. diameter, surmounting a very conical base placed over a chandelier of 34 burners, and terminated by a conical ajutage, the edges of which were inclined 45° to the axis, and which had successively diameters of 0·210; 0·200; 0·180; 0·158; 0·182; 0·115; and 0·080 metres.

In all these experiments, were observed, the external and internal temperature range and the velocity of the air in the pipe, or at its upper termination; the results of these observations were compared with the theoretical formula

$$v_1 = \sqrt{\frac{2 g a H (t - T)}{1 + \left(\frac{1}{m} - 1\right)^2 + \left(\frac{m_1 A_1}{A}\right) + \frac{28 L}{D} \beta}}.$$

This comparison shows that, in these three series of experiments, the results of observation follow as in the preceding cases, the law of the formula. But as this formula does not take into consideration the losses of heat produced by the thin metallic walls of these chimneys, it is necessary in every case to apply to it a co-efficient of reduction, the mean value of which differs very little from 0·8; which shows within what limits the exactness of the theory explains the natural effects.

If the difficulties of the question and the uncertainties of the observations are taken into consideration, and if it be remembered that the greater part of the theories of applied mechanics, and especially that of water-wheels, often do not offer so regular an agreement with observation, it will be no doubt admitted that the formula which we have reached, may be employed in the study of ventilation with as great a degree of exactness as the requirements of the art demand.

Graphic Representation of the Formulæ and of the Experiments.—When we remark, moreover, that for each peculiar arrangement in which the material data remain the same, and for a determinate mean external temperature, the preceding formula may be put under the form $v^2 = N(t - T)$; which is the equation of a parabola, or more simply, that of a straight line passing through the origin of the co-ordinates, the abscissæ of which are the difference of temperatures $(t - T)$, and the ordinates, the squares of the velocities. It may be concluded that, as this straight line may be determined by means of a single well-made observation, we shall thus have, by graphic construction, all the velocities corresponding to the different temperatures, and reciprocally; which conclusion will permit us to solve, without calculation, several interesting questions of application.

Conclusion.—It is seen by this analysis of the researches which I have the honor to present to the Academy, that the application of the principle of living-forces, or of the transmission of work to the movement of the air in chimneys, or apparatus for ventilation by draft, leads to formulæ which, in very different cases, are found in accordance with experiment. These verifications are relative:—

1st. To the practical formula which observation had led M. Guerin to adopt for ordinary ventilation-chimneys.

2d. To the introduction of hot air by the stoves of the wings of the Hospital Lariboisière, heated by the circulation of water.

3d. To the ventilation in general of these wings, both in winter and summer.

4th. To three sets of direct experiments made on metallic chimneys.

From this general accordance of the formulæ with the results of experiment, it appears, therefore, allowable to infer, that we may, without fear of notable error, calculate beforehand the effect of different systems of ventilation by draft, and deduce laws which will be useful in building.—*Comptes-Rendus de l'Academie des Sciences*, 24th February, 1862.

Preserving Timber.

From Herapath's Railway Journal, No. 1187.

An experiment which, if successful, will effect much in preserving ships of the Imperial navy from the dry rot, has just taken place at Cherbourg by order of the Minister of Marine. Since the introduction of steamships of war the Government has observed with regret the rapid decay of the timbers in new ships. After a careful examination it has been ascertained that this decay arises from the impossibility of leaving a new ship on the stocks for several years, as formerly, when sailing ships were built. The timber, consequently, is not sufficiently dried, and is more liable to fermentation, and afterwards to dry rot. M. de Lapparent, holding a high position as a naval constructor, has addressed a report on the subject to the Minister of Marine, and has proposed a remedy. The remedy he relies on is the carbonization of

the timber used in shipbuilding. The manner in which he proceeds to carbonize the timbers, and the secret which he retains for his own profit, is by employing inflammable gas, which is applied to the timber in the same manner as water is directed against a house on fire. It is said that the experiment made at Cherbourg in presence of M. Sochet, director of naval constructions, was completely successful. One essential advantage of the plan is the absence of all danger, which is a chief point in an arsenal. It is estimated that the expense will not exceed 10c. the square yard—gas and labor included. It has been further ascertained that one workman can easily carbonize 40 square yards during a day's work of 10 hours. Finally, the carbonization is uniform, and it does not exceed a quarter of a millimetre in thickness. It is expected that so simple and so cheap a process will be generally adopted in shipbuilding.—*Times.*

[A method of charring and preserving timber by high pressure steam, if we recollect it correctly, was mentioned in this *Herapath's Railway Journal*, the invention of a Frenchman or foreigner, many years ago.—ED. H. R. J.]

For the Journal of the Franklin Institute.

Papers on Hydraulic Engineering. By SAMUEL MCELROY, C. E.

(Continued from vol. xliii. page 366.)

No. 1.—RESERVOIR CONSTRUCTION—(Continued).

The general theory of embankment reservoir construction presented, involves a certain chain of details, each connected with, and to a certain extent dependent on, the other. The basis of the structure, on which the superincumbent weight is placed, must be firm, the banks must be built so as to guard against settlements and slides, the puddlings must be compact and solid, or the slope walls and top angles will lose their lines of symmetry, and to some extent their usefulness.

This brings us to a theory which does not seem to be as fully admitted and promulgated as is desirable, viz: that correct engineering science ought to be able, so to erect and join together, these several links of the chain, that the proper result may be obtained as a rule, bringing failures within the class of exceptions. In other words, that as to this special department of construction, as in others contingent on the same law of design and execution, engineering ought to take rank as a profession endowed with control of exact results, and not as a calling, which naturally disclaims infallibility. Without denying then the argument, that each distinct construction is subject to local peculiarities of material, we assert the doctrine, that the workmanship should overrule and insure their proper combination. To build any engineering structure with an implied reservation for defects in its progress or use, is a custom to be distinctly condemned. While we do not therefore propose here to give any rules for universal application, some allusion to methods which have secured satisfactory results, will illustrate in a brief way some of the links in this chain of construction,

as applied to embankment reservoirs with artificial slopes, and without regard to mathematical questions of stability in form.

Earth-work.—It rarely happens that a reservoir is so located as to require an embanked base for the whole structure; there is a case at Cleveland, and it certainly requires great care in formation, although a uniform settlement after the water is introduced, may obviate any injurious effects, realized when such settlement is not uniform. Here the general rules for the embankment walls also apply, which may be thus stated:—

All vegetable soil should be carefully removed from the proposed base of the embankment, nor should the foot of a slope be carried over spongy and compressible material.

Where work is partly in embankment and partly in excavation, it is best to build the heaviest banks first, so as to give them time for their additional settlement.

The section of the bank should be carried up entire, and not bisected by walls or pyramids of other material.

For the outer slope inclination, the sharpness in rate may be varied with clay, gravel, and sand in their order, flat slopes being relatively objectionable.

For the outer slope there are some advantages in the use of sodding, but seeding properly done will answer the purposes of protection from wash, &c.

The top should have a drip from the inner angle towards the outer, and the former should be protected by coping; for the other, the sod line should be returned on the top from the slope.

No banks should be built with a heavy dump, but in thin, level layers, somewhat modified in thickness to suit the material. For gravelly earth, about nine inches, less for clay, more for sand. Unless the "lead" is so great as to require the use of teams, carts are better for consolidating the layers. Water is objectionable for clay, of no use for gravel, though beneficial for sand. Rollers are also objectionable for both the former. In a case of a gravel embankment partly constructed with the use of water and rollers, I have found distinct water seams formed between each layer, which would operate badly under a reservoir head. In a case at Ridgewood Reservoir, where it was necessary in the winter to cut through part of an artificial bank, and to use gunpowder in blasting on account of its solidity, the smoke was observed to follow these seams for several feet on each side of the cut.

In side and end filling on slopes, benches should be cut. All slopes should be crowded or over-filled, so as to trim down to form, when the face is to be finished for protection from the weather, and thus obviate the effects of wash.

No slope lining should be built on the inner slopes until experiment has shown that their settlement is complete, a result which can be determined with proper care.

The inner slopes must be protected from contact with the reservoir contents, by water-tight facing.

Walls of masonry, as far as possible, should not be connected with

the banks, until the latter have come to their bearing; and water pipes leading from them should be protected by arches, or otherwise, from the effects of settlement by their back-fill.

These are some of the prominent processes in construction which insure stability.

Questions of stability are so fully guarded by the ordinary conditions of section, which is controlled by convenience of top bank width and slope angle, as to need no discussion. The principal defects are settlements after final construction of slope walls, slides, and leakage, and these may be obviated on smaller sections than convenience and effect suggest. For the enormous thrust of the water prism, the counteracting weight of the section is modified by its form and its material, sand, gravel, and clay having relative weights per cubic foot of 95, 124, and 165 pounds, as compared with water at its maximum weight of 62·382* pounds, and being therefore largely in excess.

Puddling.—A mixture of clay and gravelly earth is better than pure clay. What is known as "hard-pan" is a specimen of natural puddling. At Ridgewood, in making 82,150 yards, 44,000 of clay and 51,500 of gravel were used, the shrinkage being about 14 per cent. The materials were carted or wheeled on in thin alternate layers, to an aggregate depth which would work down to about 8 ins. for each general layer, gangs of men being employed in spading and mixing them. As little water was used as possible, to prevent the effect of subsequent shrinkage by evaporation. Some engineers make their puddling entirely dry, preferring material which will work close, and their theory is undoubtedly correct, as to the prevention of settlement and fissures. But gravel is always an improvement in mixture, and in certain forms of puddle walls, they may be more advantageously worked with a limited use of water. The object is to obtain a compact, impervious, homogeneous mass, not only to prevent filtration, but to distribute weight uniformly over the sustaining slope or bottom earthwork.

It is a difficult matter to make puddling tight at the joints, when connected with other materials, and frequent breaks in the joint surface are therefore advisable; nor is it easy to make a water joint on wood, in connecting with sheet piling or flooring. On division banks, at gate-houses, the masonry backing should be built with buttresses, and the faces left rough, to take the puddle walls, and prevent continuous threads of water under pressure.

Slope puddling is to be preferred to vertical, inner, bank walls, on the ground of economy in material, ease of access, prevention of bank saturation and its results, facility of construction, preservation of bank-section, and distribution of pressure; and in all cases, it should be connected with the bottom puddling, the latter (or its equivalent) being assumed indispensable. It will be found, in laying it, that some compression of the bank face occurs, though not large, which should be accomplished before the cement masonry is built.

* Instead of 62·5, as commonly assumed.

Concrete.—This, as lining, may be made to serve two important purposes: one, in being carried up with the slope puddling, as a protection to its face from wash, while coming to its bearings; and another, as an additional means of tightness, and a break line of surface, to the courses of face masonry, whether of brick or stone. It may be made in a thin layer, and should be carefully prepared with fresh hydraulic cement mortar.

In the use of concrete for the various purposes to which it is admirably adapted, it is sometimes forgotten that it is only, after all, an improvement on ordinary masonry in convenience of application, and as to its proportion of cement mortar, ought to be governed by the same rule, viz: that weight is to be resisted by the pressure of face upon face, and the chief object of mortar is to fill up crevices and irregularities, and distribute uniformly the load over the surfaces in contact. Consequently, in concrete, no more mortar should be used than will properly fill up the interspaces of gravel and stone. This applies more particularly to foundations, as in thin slope lining, a cement face is not as objectionable. A certain proportion of screened gravel, with the basis of broken stone, is an improvement in filling up more completely the openings. In an extensive use of concrete at the Brooklyn Navy Yard, five parts of broken stone, with two of gravel, made, when properly added to the mortar, a very solid mass.

Brick-work.—The first care in brick masonry is that of proper selection. Very little attention is paid to the process of manufacture at the yards, which is open to objection as to the material and the burning. If the clay is charged with an efflorescent salt, which will appear after the masonry is laid, and frequently spalls off parts of the face, the work is injured; and from the rudeness with which the kilns are built and burned, part of the bricks are vitrified and spoiled, part well burned, and the rest, half or less than half baked. Until these defects are more carefully guarded, as they can and should be, great precaution is needed in inspection. The second care is that of mason work. Here it is requisite to have the bricks properly moistened to prevent the effects of too rapid absorption on the mortar, which should be carefully mixed, and laid with close joints. Brick-work is injured for hydraulic purposes, by want of attention to this point, and the joints fail after short exposure, with a bad effect on appearance, tightness, and durability. With proper attention, however, in selection and construction, a comparatively light brick wall can be made much more tight, with much more symmetrical and ornamental appearance, than rubble work.

In face work of structures, there is considerable range of cost and ornament, in the use of pressed bricks and close putty joints. In work which requires the use of arches to sustain weight, or for appearance sake, the use of moulded arch bricks, or for plainer work, of alternate "headers" and "stretchers," ought to be maintained, since a "row-lock" arch has neither beauty nor strength; and in all cases where the stability of the arch is important, the centres should be struck as soon as the keys are driven home, to bring each member to its bear-

ing, and expose any weak points before the backing is carried up to any height.

Stone Masonry.—For ordinary rubble work, in which "bank" stone or quarry stone are used, the least thickness which can be conveniently worked is about sixteen inches on slope lining. In point of quality, as a general rule, the former, having come down to us through the action of floods and time exposure, as water-worn boulders, are to be preferred, although defective boulders as well as defective quarry stone are not uncommon. This is a matter of inspection, selection, and relative cost, in special localities, certain classes of quarried stone being, of course, unexceptionable.

The objection to the use of rubble masonry lies partly as to its rough appearance, and partly as to the difficulty of teaching masons to make close and solid work, the craft being, as a rule, strongly disposed to work with wet and soft mortar, and to neglect the proper use of spalls, whence follow, in too many instances, the usual building and wall settlements and fissures; for if the walls were themselves solidly jointed, the foundations, with ordinary care, would be more evenly pressed. This assumes, of course, the use of due precaution in foundations, for a broad and uniform bearing, fully guarded against the contingency of water threads, by puddling or concrete, with sheet piling, as the special case may require.

The use of dry stone walls, in rubble work, for reservoir slopes, is unequivocally condemned, the mass of testimony against them being conclusive, with the ordinary thicknesses in practice. Nor is their economy in first cost a matter of very positive demonstration. Their beds are continually exposed to undermining by rain wash while building, and to wave wash while in use, and the walls to injurious effects from frost and otherwise.

For other kinds of stone masonry, which pertain rather to superstructure, we need only refer to well known principles and methods in use, without special designation. The same principle of jointing and construction controls them.

Nor is this brief memorandum intended to cover all the points to be considered in these parts of reservoir workmanship, but rather as allusions to certain details in method, which are sometimes overlooked, and which tend to produce and insure desirable results without much additional cost. A few words also, in reference to general plan of structure, will conclude this branch of our subject.

Division Walls.—For purposes of cleansing, repair, subsidence, æration, circulation, and their attendant benefits, and for reduction of areas exposed to surface waves, it is always desirable to build reservoirs with one or more division walls. No reservoir can be considered complete with less than one, and with water which requires much care, the number may be increased with great advantage. The several divisions of the Fairmount Reservoirs at Philadelphia, may be instanced as an evidence of the manner in which impure river water may be much improved, and a recent report on the Delaware Reservoir at the

same city, shows that the deposit is about one inch per month, as a comment on subsidence and surface supply. It is customary in some instances to build these division walls below the ordinary flow line; but while this may accomplish a certain use of surface supply, it is open to the objection of exposed area, which becomes serious in the case of large sheets of water. The heads of these submerged walls are also subject to the action of breakers, in a different manner from that due to slope wash.

Connecting Weirs are therefore preferable, arranged with a gate pier, and with gates which open downwards from the surface in alternate positions, for a given depth. Pipes may be built across the foot of the division wall for bottom drainage at any time. With weirs of this kind, which are readily built, and which can be managed at will, a very complete and desirable control may be had over the contents of the separate divisions, and a positive supply of the purest water secured.

Gate Houses may be also arranged so as to secure the general principles of action discussed. For gravitation supplies, the influent chamber may be arranged for the top bank, with suitable descending channels; but for pumping supplies, it should permit an accommodation, by a proper gate pier, of the engine load either to the flow line head or that of the actual reservoir level. By this means, if the engine be properly designed and managed, in many cases a very important saving may be made in annual cost of pumping.

For effluent chambers, it may be assumed as a rule, that the gate piers should be so arranged as to take only a surface supply at all times for domestic and public use, and to waste occasionally the bottom strata by suitable blow-offs. Too much importance cannot be attached to this law, which involves the comfort and health of the consumers to no small extent, and the reputation of the supply.

Depth of Water is also important in preventing solar action on its contents. It seems to be the European experience that less than ten feet is always objectionable, and it will be observed from our preceding papers that twice this depth is the common American standard. If this consideration obtains with distributing reservoirs, it should be urged with greater force on all fountain or supply reservoirs, which are generally natural lakes, of great area and shallow depth, constantly subject to impregnation by vegetable and other organic matter, and all the results of fermentation. Especially is it objectionable that supply reservoirs should contain a large disproportion of contents to daily supply, unless prompt and efficient means of æration, circulation, and bottom waste are provided.

These general and rapid suggestions are made, not as a professional dictum, but as the results of experimental science in a direction which needs yet more enlarged observation and trial. Water works with us are yet in their infancy, in an important sense, and are exceptions throughout the country, rather than a general rule, and several of our

most prominent supplies already warn their consumers of the necessity of early steps for an entire reconstruction and enlargement. Discussions of this kind are therefore desirable, and the best results of experience ought to be embodied in general rules of practice, similar in method, if not in detail, to those presented for consideration.

(To be Continued.)

On Railway Accidents—their Causes and Means of Prevention; showing the bearing which existing legislation has upon them. By Mr. JAMES BRUNLEES, M. Inst. C. E.

From Newton's London Journal, May, 1862.

The author proposed to treat the subject by dealing with the facts as they were, the causes of accidents being, in nearly all cases, sufficiently apparent; he would not therefore attempt, by theory, to establish rules for their prevention. From the reports of the officers of the Board of Trade it appeared that, during the seven years from 1854 to 1860, the number of accidents amounted to 540, as the result of 1274 distinct causes. Of these accidents, 11 per cent. were attributed to the permanent way, 7 per cent. to the rolling stock, and 76 per cent. to the management, including insufficient means for securing safety, leaving only 6 per cent. as not ascertained.

The accidents due to the permanent way were then referred to in detail, and it appeared that the general defects were most evident in the system of ballasting, of joint-fishing, of turning the rails, and of fastening the chairs to the sleepers. With regard to the ballast, it was argued that it would be found economical to have at least 6 ins. or 9 ins. of rough gravel or broken stone, as a free draining bed to the sleepers and to the "top-dressing;" and that, during the months of September and October, an extra number of men should be employed to drain the ballast and beat up the road, in order that it might become consolidated before the winter's rains and frosts set in, and thus avoid the evil effects of frost on wet ballast. It was urged that the plan, now in general use, of placing the fish-joint between two sleepers, was objectionable, as the ends of the rails were unsupported except by the fish-plates, which together were frequently only equal to two-thirds of the section of the rail. It was submitted that all the joints should be fished directly over a sleeper, or that a bracket chair should be used. The practice of turning the rails was condemned, because when a rail was so much worn as to require turning, its strength was generally so reduced as to render it unfit for main line traffic. With regard to the fastenings of the chairs to the sleepers, it was urged that it was desirable that iron spikes only should be employed on the outer side of curves, or else that the chair should be partially sunk into the sleeper, to lessen the strain on the treenail. The superior economy of steeled, or partially steeled, rails, points, and crossings, was also incidentally noticed.

In reference to the accidents which had arisen from defective or neglected rolling stock, it was found that many of the fractures had

occurred during the winter months, owing, possibly, in some degree, to the rigid state of the "way" in frosty weather; whilst others were due to the use of bad iron, and some to defects either in the welding of, or in the mode of attaching the tyres of the wheels. Steel, or partially steeled, tyres, were now, to a certain extent, in use, and tyres formed of a continuous ring, or unwelded piece of metal, were also successfully employed. Several new methods of fastening the tyres had proved as fruitful of mischief as the ordinary plan of simply shrinking them on, though others had been found to be efficient; and it was said that, on some lines, the tyres had not failed to any great extent. The author hoped, that the importance both of the tyres and of the axles of wheels would lead to a useful discussion on this branch of the subject. The usual want of uniformity in the main features of the carriage portion of the rolling stock was then commented upon; and it was considered that this variety not only increased the cost of manufacture and of maintenance, but was often the cause of accidents, and frequently contributed to render them disastrous. The author thought that the carriages should be nearly uniform in size, and that the buffers should, in all cases, be the same height above the rails. The longitudinal beams should be in the same line throughout, be strong in themselves, and the framing securely braced. The present coupling in the centre should be increased in strength, and the whole attachment between the carriages should be such as to render a train in effect, as far as practicable, as one carriage, with a certain amount of flexibility; so that in the event of collision, the carriages should retain their position, instead of rising upon one another; and if an axle or a wheel broke, the crippled carriage should be partially borne up by the neighboring carriages until the train could be stopped.

On the question of management, after some remarks upon the speed of trains, it was shown that, by punctuality, both in the time of starting and in the rate of running, safety, so far as human foresight was concerned, was insured. The system of working the traffic of a railway by allowing an interval of time between the trains was deemed unsatisfactory, and far inferior to the system of an interval of space. The accidents arising from the irregularity of excursion trains were then alluded to, and it was remarked that if, during the summer and autumn, the ordinary trains were run at lower rates of fares, the traffic would be increased, as the public would feel greater security in traveling. The difficulty in running coal or mineral trains to a fixed time table might be met by a more general use of the electric telegraph, and by a better system of signaling arrangements. During the seven years, from 1854 to 1860 inclusive, 88 accidents happened from inefficient signals, of which 14 occurred in 1860. In some cases, especially at sidings, there were no signals; in others they were defective in form, or were improperly placed. It was desirable that junction signals and points should be worked simultaneously by one man, and at junctions, separate main and distance signals should be provided for each line. If the system of working the traffic by the electric telegraph was generally adopted, and the line was divided into sections, so that a

train should be prevented from entering any section until the preceding one had passed to the section in advance, collisions would be impossible, except those liable to arise from disregard of the signals, and a proper interval would be secured between the trains, in spite of unpunctuality. As the want of a means of communication between the engine-driver and the guard or conductor had frequently been experienced, and as plans were in daily use on several lines, there was no reason why it should not be adopted on all. To render it fully effective, the guard or conductor ought to start the train from each station by means of that machinery, so as to prove that it was in working order. Owing to the general high speeds and heavy trains, it was of the utmost importance that ample break power, capable of being applied in the least time, should be provided with each train. It was a question how far a regularly distributed retarding force, acting at the same moment on all the wheels, might not be preferable to a concentrated force applied at particular points. By the system of "continuous breaks," the employment of several men with each train was unnecessary. It had also another advantage—that a train was more under control, and could be stopped in a shorter distance. The negligence of servants, arising from their ignorance or inefficiency, was next adverted to, and it was thought to be due to the pay being too low to command the services of men of intelligence, steadiness, and self-reliance. Frequently they were insufficient in number, leading to overwork; and instances were on record in which engine-drivers had been employed for 17 hours daily, and in some cases for 26 and 30 hours continuously.

The author proposed leaving the bearing of existing legislation upon railways to be dealt with by Capt. Douglas Galton.* He would, however, observe, that Government interference was not likely to render railways safer, or more available to the traveler; and that it would be better to rely on the consideration and calm reflection of those immediately interested in these enterprises, especially as from the heavy expenses attendant on accidents, directors and shareholders would naturally desire to render this mode of traveling as safe as possible.

Proc. Inst. of Civil Engineers, April 1st, 1862.

The Economic Angles in Parallel Open-work Girders.

From the Civ. Eng. and Arch. Jour., April, 1862.

(Continued from vol. xliii. p. 303.)

Let N be the number of bays into which the span S is divided by the points of concentration of the loading. Let θ represent in a general manner the angle which a brace makes with the vertical direction, and V the vertical component of the stress upon the brace.

In our last paper, we have shown that when N is of any previously assigned value, the economic values of θ, as calculated for the bracing taken alone, will also be the economic values of θ for the whole girder, that is, for the bracing and booms taken together. The question is, therefore, reduced to the determination of the economic angles for

* Captain Galton's paper will be published in the next number.

the bracing. This, however, ignores the end pillars: but as these more properly belong to the piers, and may, in fact, have no separate existence, they may very properly be excluded from the more general investigations; but in some of the examples to be given in our next paper, their influence will be pointed out.

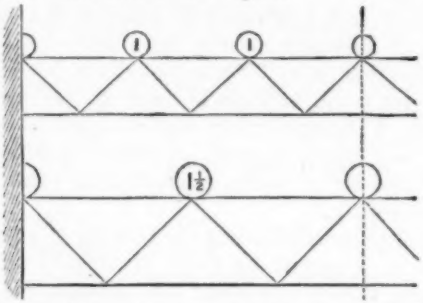
The Effect of the Depth of the Girder upon the Weight or Cost of the Web.—Before proceeding to the more immediate objects of this paper, we may here state at somewhat greater length a fact first published in 1855 (see vol. xviii., page 236): we refer to the constancy of the amount of material required for the bracing of an open-work girder, when the values of S, θ, W, and a* are constant, although the value of D, and with it the amount of the material in the booms, may undergo any degree of change.

This will be most convincingly shown by direct calculation of some extreme examples.

Let us assume, then, as in some of the cases in our last paper, that $S = 12$ units, $\theta = 45°$, and $W = 6$ units, and that the braces are in pairs, or the numbers of struts and ties equal.

Fig. 1.

Fig. 2.



Now, the weight of any brace is $= V \cdot D \cdot \sec.^2\theta \cdot a$; and since here we have $\sec.^2\theta = 2$, and $D = S \div 2N$, and the portion of the loading at each supported point $= W \div N$, the material in the bracings for the case of a fixed load, half only of each structure being taken, will be as follows:—

Fig. 1.

$N = 6$, $D = 1$ } Bracing $= (\frac{1}{2}+1\frac{1}{2}+2\frac{1}{2})D\,2(a_1+a_2) = 9(a_1+a_2)$

Fig. 2.

$N = 4$, $D = 1{\cdot}5$ } Ditto $= (\frac{3}{4}+2\frac{1}{4})D\,2(a_1+a_2) = 9(a_1+a_2)$

$N = 2$, $D = 3$ } Ditto $= (1{\cdot}5)D\,2(a_1+a_2) = 9(a_1+a_2)$

$N = 12$, $D = 0{\cdot}5$ } Ditto $= (\frac{1}{4}+\frac{3}{4}+1\frac{1}{4}+1\frac{3}{4}+2\frac{1}{4}+2\frac{3}{4})D\,2(a_1+a_2) = 9(a_1+a_2)$

So that, in the case of a fixed loading, there is absolutely no change produced on the amount of the material in the braces, estimated with fixed values of a_1 and a_2.

On the other hand, when the loading is treated as wholly movable, we find that on increasing N, the increase of the stresses on the braces

* For the meaning of the symbol a, see *ante* vol. xliii. p. 298.

resulting from the mobility of the load, is augmented. The calculations are more complicated than the above; but the results given below will show the character of the increase. (See table following.)

If we exclude from these results the exceptional case of N = 2, we see that the variations produced in the amounts of material in the bracing, by changes in the value of D, are very moderate, even when all the loading is treated as movable. When, however, the question is treated practically, the slight advantage shown on the side of a high value of D will be more than destroyed by the necessary increase of a_2 for the struts on account of their increased lengths.

N =	2	4	6	8	10
D =	3	1·5	1	0·75	0·6
Material in Bracing when loading all fixed, =	9	9	9	9	9
Material in Bracing when loading all movable, =	9	10·125	10·333	10·406	10·440

The Economic Angles for the Struts and Ties of the Bracing.—In the following investigation, we shall confine ourselves to the consideration of structures made up of an even number of triangles, or, in other words, an equal number of ties and struts; further, we will assume that the loading is all collected at the upper or lower boom of the girder. Under these circumstances, the braces are arranged in pairs, each of which pairs consists, as in fig. 3, of a strut and a tie having the vertical components of their stresses equal.

Let a_1 represent the cost, weight, or bulk of a *tie* constructed of the material of the ties (*a*—*b*, &c.), and capable of conveying one ton of stress through one foot of length. Similarly, let a_2 represent the cost, or other quality to be considered, of a *strut*.

Now, all that is required is to determine the two values of θ for each pair, viz: θ_1 for the tie *a b*, and θ_2 for the strut *c b*; and so long as the values of a_1 and a_2 bear the same proportion to one another, the angles obtained for any one pair will be those also for all the others, since the question is not affected by the absolute amount of the vertical component V of the stresses to be transmitted through the braces. Should, however, the ratio of a_1 to a_2 vary for the different pairs, the

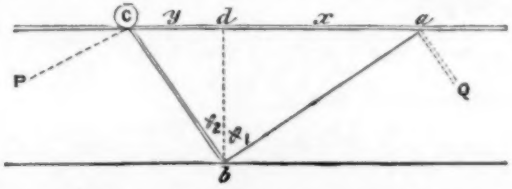


FIG. 3.

economic values of θ must be obtained by so many independent calculations.

Let V be the accumulated portion of the loading on the P side of point c and at point c, which it is necessary to convey to the pier on the Q side. The stresses on the braces will consequently be $=$ V sec. θ. Let the depth $ab =$ D, then the lengths of the braces will be $=$ D sec. θ. The work performed by these braces is the conveyance of V towards Q; hence, the amount of such work done by any brace, or its efficiency, is expressed by V D tan. θ.

Now, let it be the *cost* of a brace, in proportion to the work done by it, which is to be rendered a minimum; this is represented by V sec. θ . D sec. θ . $a \div$ V D tan. $\theta = a \sec.^2\theta \div \tan.\theta$, or we have for the pair—

$$\text{cost} \div \text{efficiency} = \frac{a_1 \sec.^2\theta_1 + a_2 \sec.^2\theta_2}{\tan.\theta_1 + \tan.\theta_2} = \frac{a_1(x^2+1) + a_2(y^2+1)}{x+y} \quad (1)$$

Let $x+y=s$.

The cases, the solutions of which follow, are,

1. When s is fixed, but x and y variable.
2. When s, x, and y are all variable.
3. When $x \div y$ is fixed.
4. When x or y is fixed.
5. When x or $y = 0$.

Case 1. In equation 1, by substituting s for $x+y$, and $s-x$ for y, we get:

$$\frac{\text{Cost}}{\text{Efficiency}} = \frac{1}{s}(a_1x^2 + a_1 + a_2s^2 - 2a_2sx + a_2x^2 + a_2).$$

Differentiating this with x as the variable, putting the co-efficient $= 0$, and reducing, we get for a minimum, when s is constant,

$$\left.\begin{aligned} x &= s\frac{a_2}{a_1+a_2} \\ \text{and similarly we have} \quad y &= s\frac{a_1}{a_1+a_2} \end{aligned}\right\} \quad \ldots\ldots\ldots \quad (2)$$

Whence $x : y :: a_2 : a_1$; and $x = y\frac{a_2}{a_1}$, and $y = x\frac{a_1}{a_2}$.

So that, whatever value may be assigned to s, the tangents of θ will be to one another inversely as the values of a.

Case 2. We have now to determine what value of s will give the absolute minimum value to equation 1.

Substituting for x and y in equation 1, their values as given in equations 2, we get,

$$\frac{\text{Cost}}{\text{Efficiency}} = \frac{1}{s}\left\{ a_1s^2\left(\frac{a_2}{a_1+a_2}\right)^2 + a_1 + a_2s^2\left(\frac{a_1}{a_1+a_2}\right)^2 + a_2 \right\} \quad (3)$$

The differential of this is

$$= \left\{ 2a_1s\left(\frac{a_2}{a_1+a_2}\right)^2 + 2a_2\left(\frac{a_1}{a_1+a_2}\right)^2 \right\}\frac{ds}{s} - \left\{ a_1s^2\left(\frac{a_2}{a_1+a_2}\right)^2 + a_1 + a_2s^2\left(\frac{a_1}{a_1+a_2}\right)^2 + a_2 \right\}\frac{ds}{s}.$$

Putting the differential co-efficient = 0, for a minimum, and reducing, we get,

$$s = \frac{a_1 + a_2}{\sqrt{a_1 a_2}}.$$

Substituting this value of s in equations 2, we have,

$$x = \frac{a_2}{\sqrt{a_1 a_2}} \text{ and } y = \frac{a_1}{\sqrt{a_1 a_2}} \quad \ldots\ldots\ldots \quad (4)$$

Further, we have, $xy = 1$, $\therefore\ \theta_1 + \theta_2 = 90°$.

Table of Economic Angles, &c., calculated by Equation (4).

$a_1 : a_2$.	y.	x.	θ_2.	θ_1.	s.
1 : 1	1·000	1·000	45° 00′	45° 00′	2·000
1 : 1·5	0·816	1·225	39 14	50 46	2·041
1 : 2	0·707	1·414	35 16	54 44	2·121
1 : 3	0·577	1·732	30 00	60 00	2·309
1 : 4	0·500	2·000	26 34	63 26	2·500
1 : 0·5	1·414	0·797	54 44	35 16	2·121

Case 3. When a definite value is assigned to the ratio of $x : y$.

Let $x = cy$, then $x : x + y :: c : c + 1$, and

$$x = s\frac{c}{c+1} \text{ and } y = s\frac{1}{c+1}.$$

Substituting these values of x and y in equation 1, we have,

$$\text{Cost} \div \text{efficiency} = \frac{1}{s}\left\{ a_1 s^2 \left(\frac{c}{c+1}\right)^2 + a_1 + a_2 s^2 \left(\frac{1}{c+1}\right)^2 + a_2 \right\};$$

differentiating, and putting the co-efficient = 0, arranging and reducing, we get for a minimum,

$$x = \left(\frac{a_1 + a_2}{a_1 c^2 + a_2}\right)^{\frac{1}{2}} \text{ and } y = \left(\frac{a_1 + a_2}{a_1 c^2 + a_2}\right)^{\frac{1}{2}}. \quad \ldots \quad (5)$$

When $c = a_2 \div a_1$, we have the absolute minimum as by Case 2.

Table of Examples.

$a_1 : a_2$	c.	s.	θ_2	θ_1
1 : 1	2	1·897	32° 19′	51° 40′
1 : 3	2	2·268	37 5	56 31.

Case 4. When a given value x_1 or y_1 is assigned to one of the tangents, the other and s being variable.

Let x be the variable tangent, then equation 1 becomes,

$$\text{Cost} \div \text{efficiency} = \frac{a_1 x^2 + a_1 + a_2 y_1^2 + a_2}{x + y_1}.$$

Which, by the calculus, we ascertain to be a minimum, when

$$\left.\begin{aligned} x &= \sqrt{\left(1 + \frac{a_2}{a_1}\right) \cdot (y_1^2 + 1)} - y_1 \\ \text{and, similarly,} \quad y &= \sqrt{\left(1 + \frac{a_1}{a_2}\right) \cdot (x_1^2 + 1)} - x_1 \end{aligned}\right\} \quad \ldots \quad (6)$$

Table of Examples when $a_2 = 2\,a_1$.

When $x_1 = 0{\cdot}5$, $y = 0{\cdot}8693$	When $y_1 = 0{\cdot}5$, $x = 1{\cdot}4365$
" " $1{\cdot}0$, " $0{\cdot}7320$	" " $1{\cdot}0$, " $1{\cdot}4495$
" " $1{\cdot}5$, " $0{\cdot}7079$	" " $1{\cdot}5$, " $1{\cdot}6225$.
" " $2{\cdot}0$, " $0{\cdot}7386$	
" " $4{\cdot}0$, " $1{\cdot}202$	

Case 5. When one of the braces is perpendicular, x_1 or $y_1 = 0$, and equations 6 become,

$$x = \sqrt{1 + \frac{a_2}{a_1}},\quad y = \sqrt{1 + \frac{a_1}{a_2}}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Table of Examples.

$a_1 : a_2$	θ_2 x being $= 0$.	θ_1 y being $= 0$.
1 : 1·0	54° 44′	54° 44′
1 : 1·5	52 14	57 41
1 : 2·0	50 46	60 00
1 : 3·0	49 6	63 26.

We now offer some applications of these formulæ.

TABLE I.—*Of Results for Various Examples arranged to exhibit the Per Centage of Excess of Cost or Weight or Bulk, incurred by a Departure from the Economic Values of the Angles.*

We here assume that $a_1 = a_2$, ∴

Cost or weight or bulk ÷ efficiency, varies at $\frac{x^2+y^2+2}{x+y}$.

x.	y.	θ_1.	θ_2.	Per centage of cost.	REMARKS.
1·000	1·000	45°	45°	100·00	Absolute minimum of cost. Published in January, 1851, by the writer, in his "Treatise on Bracing."
0·577	0·577	30	30	115·47	Warren & Monzani's Patent, 15th August, 1848.
0·425	0·425	23	23	139·00	Nash's Patent, 21st February, 1839. See *Newton's Journal*, vol. 15, p. 355.
0·557	1·056	30	46 33′	105·59	Economic value of θ_2 when $\theta_1 = 30°$.
1·732	1·732	60	60	115·47	
1·414	0	54 44′	0	141·42	Economic value of θ_1 when $\theta_2 = 0$.
1·000	0	45	0	150·00	American "Rider" Bridge, shown at Exhibition of 1851. Cast iron perpendicular struts, and wrought iron ties.
2·667	0	69 27	0	170·83	1851 Exhibition Building, 48 feet girders (approximately).
0·268	0·268	15	15	200·00	Chelsea Suspension Bridge, principal girders.

TABLE II.—*General Examples to exhibit the Additional Cost incurred by Various Departures from the Economic Values of* θ.

a_2 is here assumed to be equal to $2\,a_1$, $\therefore$

Cost $\div$ efficiency varies at $\frac{x^2+2y^2+3}{x+y}$, and for the per centages given in the table, this is divided by 2·8284.

x.	y.	θ_1.	θ_2.	Per centage of cost.	REMARKS.
		° ′	° ′		
1·414	0·707	54 44	35 16	100	Absolute minimum of cost.
1·061	1·061	46 41	46 41	106·20	In these five examples, the value of $x+y$, or s, is made constant, and $= 2{\cdot}1213$, or that required for the above minimum.
2·121	0	64 46	0	125	
0·707	1·414	35 16	54 44	125	
0	2·121	0	64 46	200	
1	1	45	45	106·1	
1·449	1	55 24	45	102·5	Minimum when $y = 1$.
2	1	63 26	45	106·1	
1	0	45	0	141·4	
1·5	0	56 19	0	123·7	
✓3	0	60	0	122·4	Minimum when $y = 0$.
2	0	63 26	0	123·7	
1	0	45	0	141·4	
1	0·732	45	36 12	103·53	Minimum when $x = 1$.
1	2	45	63 26	141·4	
2	0	63 26	0	123·7	
2	0·739	63 26	36 27	104·46	Minimum when $x = 2$.
2	2	63 26	63 26	132·58	
0	1	0	45	176·8	
0	✓1·5	0	50 46	173·2	Minimum when $x = 0$.
0	1·5	0	56 19	176·8	
4	1·202	75 58	50 15	148·77	Minimum when $x = 4$.
2·605	0	69	0	144·30	C. P. Sydenham, cast iron girders (approx.)

In our next paper, we purpose treating of some of the more practical applications of the principles discussed above. R. H. B.

EDINBURGH.

For the Journal of the Franklin Institute.

Remarks concerning Surveys of the Atrato River. By JOHN C. TRAUTWINE, C. E., Philadelphia.

In reading the Report on the recent Survey made by order of the United States Government, of a route for an inter-oceanic canal by way of the Rivers Atrato and Truando in New Granada, I find the following remark on page 199 in the portion devoted to the botany of

the explored region, and prepared by Mr. Arthur Schott, naturalist and geologist to the expedition:

"We take occasion to here express our astonishment about Mr. J. C. Trautwine's remark in his 'Rough Notes of an Exploration for an Inter-oceanic Canal,' see page 2, where he uses the following words: 'Still I do not remember to have seen a single large tree growing throughout the entire course of the Atrato.' Either Mr. Trautwine or ourselves must have had a different standard of judging dimensions of tropical trees; or those gigantic ceibas, robles, cedros, trementinos, and other large trees, especially of the leguminous order, must have grown up since Mr. T.'s visit in 1853. There stands a large ceiba in the outskirts of Turbo, which can be singled out by its gorgeous growth almost from the middle of the Bay of Uraba. At Sucio, close to the landing, is leaning against the river banks, with its main portion submerged, the broken trunk of a ceiba, which we measured as closely as possible, and found to be between 10 and 12 feet in diameter."

Since discrepancies in the representations of different persons describing the same thing, have a tendency to impair confidence in both; and inasmuch as I truly desire that the cloud which has so long obscured the truth in regard to the various proposed inter-oceanic routes, may be gradually dispelled, I considered it as conducive to that end to remove the source of doubt even in a matter of so trifling importance as that involved in the above extract from Mr. Schott's report. Its origin in this case could not be more aptly expressed than by the words quoted above, intimating that the parties had adopted different standards for judging of the dimensions of tropical trees. My standard had been formed in the lower portions of the valley of the River Magdalena, which flows nearly parallel to the Atrato, but on the eastern side of the Cordillera ranges which separate the two. In this region I had previously passed four years; and in it, trees of from 6 to 8 feet in diameter for great heights are quite common; and considerably larger ones are by no means rare. Mr. Schott has not informed us whence his standard was derived.

On commencing my ascent of the Atrato, the comparative diminutiveness of the trees was a source of much surprise, not only to myself and Mr. McCann, who had been with me on the Magdalena; but also to Dr. Halsted, a pupil of the distinguished botanist Dr. Torrey, and himself a botanist of no small attainments. It was a subject of daily comment among us.

Mr. Schott, however, has not quoted my remark as accurately as he might have done. In the first copies of my "Notes" that were struck off by the printer, it reads: "Still I do not remember to have seen a single 'really' large tree growing throughout the entire course of the Atrato;" in the subsequent copies, the words ("exceeding say 3 feet in diameter") were inserted. The word "really" omitted by Mr. Schott in his quotation, was intended, as must be apparent to every reader, to imply that I meant trees of somewhat larger than the ordinary growth seen every day in non-tropical countries.

I did not of course stop my boat, and land, in order to measure such trees as might have proved to be even 3 feet in diameter, inasmuch as the fact was in itself one of no imaginable importance to the object of my survey; still I doubt whether there is a single tree growing on the banks of the Atrato which attains to that size, unless perhaps near to the ground. The ceiba tree at Turbo alluded to by Mr. Schott is shown in one of the engravings which accompany my published "Notes;" consequently it has not grown there since my visit. It did not appear either "gorgeous" or "gigantic" to any of my party; but merely *respectable*, as estimated by the *Magdalenic* standard. Had it, however, been as much as 20 feet in diameter, it would not have conflicted in the slightest degree with the correctness of my assertion; inasmuch as *it is not in the course of the Atrato* at all; but on the opposite side of the Gulf of Uraba, distant some seven miles from the nearest mouth of the river, and exposed to growth-modifying influences very different from those existing along the natural levees of the lower Atrato.

Nor did the large tree-trunk at Sucio escape either my observation, or my tape-line. Surprised at seeing apparently a striking exception to our previous experience, I took the precaution to ask *where it came from;* but the persons to whom I applied could not inform me. It had evidently been *cut*, perhaps with the intention of making a boat of it; and had probably escaped during some high flood, and floated from *the interior country*, down the Sucio, or some other tributary of the Atrato, until it grounded at the village of Sucio. It certainly did not grow where it now is, or the people could have told us so; and we should have seen its stump. Large trees do grow in the interior, several miles back from the river.

I therefore find no reason to modify my original remark, as to *the size of the trees which I saw growing along the entire course of the Atrato.*

Inasmuch as my survey of the inter-oceanic canal route by way of the Atrato and San Juan was chiefly made by myself (Mr. McCann's attention was directed to the traveling arrangements, and Dr. Halsted accompanied me as a botanical amateur), I feel gratified to perceive that so far as my route coincided with that of the late Government survey, viz: as far up the Atrato as the Sucio, and Truando, about 70 miles, there are no discrepancies which seriously affect the more essential points to which my attention was directed; and that even in those of minor importance, the coincidence is quite as close as could be expected between a mere hasty reconnoissance made by one person only; and a detailed survey made by a full corps of scientific persons, under the patronage of the Government, and subject to none of the embarrassing restrictions as to time or convenience by which I was trammeled. Even the individual bends and reaches of the Atrato throughout that entire distance, as protracted by myself from my own bearings taken with a boat-compass, correspond quite closely *in direction* with those of the Government survey. No means were available by me for correctly measuring the *distances* along the river; and as stated in my

"Notes," I was compelled to depend chiefly upon my eye, aided by occasional measurements of the rate at which my boat was pushed along. By these means I made the distance from the mouth of the Atrato to the village of Sucio to be 63 miles; whereas the Government survey, by measurements also only approximate, but still considerably more reliable than mine, makes it 73 miles.

The correspondence of my soundings with those of the Government survey is very satisfactory; both give assurance of a channel depth of 50 feet throughout the entire distance from near the mouths of the Atrato, to the Truando.

I notice on page 162 of the Government report, that the width of the Atrato at the mouth of the Truando is set down at about 1000 yards; whereas my measurement in the immediate vicinity gave but 350 yards. Although, as avowed in my "Notes," I did not aim at any thing more than mere approximate results (such only as could be expected from a rapid reconnoissance by one person over several hundred miles of route), yet I have no hesitation in asserting positively that in this instance the error is not on my part. The Atrato is *nowhere* 1000 yards in width, nor even near so much. The error is I presume merely a typographical one, as it is perfectly impossible that the high authority under which it is set forth, could even accidentally have committed such an oversight in observing. If my supposition is correct, it appears to me desirable that the mistake should be rectified, in order to reduce as far as possible all grounds for distrust on the part of searchers after the pure facts. I am confident that my measurement is correct within a few yards; which is as close as I cared to have it.

At the risk of becoming tiresome to the reader, I will avail myself of this opportunity to correct a statement emanating from a different source, which had almost escaped my recollection, and to which I now allude only from the wish to prevent as far as I can, even trifling misapprehensions respecting my survey of the Atrato route. Mr. Lionel Gisborne, the English engineer to whom was confided the making of a preliminary reconnoissance across the Isthmus of Darien, along the route afterwards traversed by Lieut. Strain's party, stated at a meeting of the Institution of Civil Engineers at London (see Minutes of Proc. Inst. Civ. Eng., 1856, vol. 15, p. 398), that on my survey of the inter-oceanic route, I had no spirit-level; but only two aneroids, which I compared at Carthagena with the standard barometer taken out by Mr. Gisborne.

Mr. Gisborne and myself met at the City of Carthagena, while on the way to the fields of our respective operations; his on the Isthmus; mine up the Atrato. I had the pleasure of lending him a map of the Isthmus, which was more complete than those with which he had provided himself; and of which he made a traced copy for his future use. On one occasion when Mr. Gisborne called on me, Mr. McCann, who was at the time engaged in my traveling preparations, casually brought into the room my aneroid, pocket-sextant, and some other small surveying instruments, which Mr. Gisborne examined. Happening to see

no other instruments, he appears to have inferred, rather hastily, that I had none; but in fact I was fully provided with a first class spirit-level, transit, and all other appliances essential to my purpose. Any engineer who should previously have seen Mr. Gisborne's statement, would have just cause to doubt the accuracy of my published levels across the dividing ground between the sources of the Atrato and the River San Juan. As these rivers flow respectively into the Atlantic and Pacific, the reliability of those levels constitutes an important consideration in the features of that route; and they could not have been made in the detail with which I have furnished them, by means of the aneroid only; the spirit-level was necessary for that purpose; and consequently Mr. Gisborne's assertion, before so eminent an assembly of intelligent gentlemen, that I was unprovided with that instrument, must produce distrust not only concerning my veracity, but also in reference to a fact of great geographical interest; and that unfortunately among the very persons by whom, above all others, the simple knowledge of the facts could be most efficiently made subservient to useful purposes.

I actually had but one aneroid with me; it had been carefully compared for some months with standard barometers in the University of Pennsylvania, by my friend, John F. Frazer, Professor of Natural Philosophy in that Institution. Indeed, it belonged to him, and was loaned to me because of its having been so carefully tested. I was not aware, until I saw it so stated by Mr. Gisborne, that I had myself compared it with *his* barometer in Carthagena.

In the volume of the Minutes of the Proceedings of the Institution of Civil Engineers, above alluded to, I observe that surveys of the head waters of the Atrato have also been made since mine; and that they were entirely confirmatory of my own, as published in my "Rough Notes." This is, of course, highly gratifying to me; as is also the fact that the character of the route across the intervening country between the Atrato and the Pacific, was found by the Government survey to accord closely with my pre-asserted opinion upon it, based upon mere spy-glass observations, made as I passed along it while ascending the Atrato; and afterwards, along its opposite side, while coasting the Pacific. Indeed, I have met with no expression of dissent from my own observations, except the two just alluded to, by Messrs. Schott and Gisborne; and I trust that my explanation of these will be considered satisfactory.

The great difference between others and myself, as regards the *cost* of an inter-oceanic canal, is of course a matter of opinion; and does not affect our several ideas of the topography of the region. As stated in my "Notes," I conceive that the expense of such an enterprise, will for a long time secure to the Panama Railroad an effective monopoly of inter-oceanic traffic across the Isthmus of Darien.

Although the River Truando is shown on my published map, its name was not inserted, because the pilot of my Atrato boat did not know it; and upon him I depended for the names of the several streams which I noted down.

MECHANICS, PHYSICS, AND CHEMISTRY.

On Explosions Produced by Nitre in Burning Buildings, etc.

By URIAH A. BOYDEN.

From the Boston Post, May 9, 1862. Communicated by the Author.

I will first mention some occurrences which were generally known. Explosions happened at some of the buildings which at sundry times burned while they contained nitre: as at the schooner *Sarah* at Central wharf in Boston in August, 1835; at Parker, Howard and Co.'s store, and also at B. S. Woolley's store in New York in December, 1835; at Crocker and Warren's store in New York in July, 1845; at R. V. W. Thorne and Co.'s warehouse in Brooklyn in July, 1850; at John Brock's store in Philadelphia in July, 1850; and at a warehouse at Cotton's wharf in London in June, 1861. About half of the chemists who published their views of this theme, believed nitre produced such explosions, but without giving entirely convincing proof; while other chemists, including five of New York, employed by the Common Council of New York to investigate the cause of the explosions at Crocker and Warren's said store, could not discover how such explosions could have been produced by any things said to have been in the store. And some people who prepare and use nitre, infer from their knowledge of it, that it requires to be commingled with appropriate material, so that its mixture may burn somewhat as gunpowder burns, to produce such explosions as occurred at said buildings. Present circumstances induce me to explain this topic.

Nitre, in the modern nomenclature of chemistry, is called nitrate of potassa or nitrate of potass; which is in part so easily decomposed by heat, that such combustible substances as dry wood, burn intensely with it, and evolve aeriform fluids so rapidly that if the burning mass is confined only imperfectly, the fluids which it so evolves may burst their inclosure. The ship *Virginia* seems to have had its deck raised by such evolution of fluids, in May, 1845, a few days after it left Calcutta: and an explosion occurred at this ship about a minute after its deck was so raised. Such deflagrating does not evolve aeriform fluids suddenly enough to make a pop or clap; unless the nitre is inclosed with the fuel, or thoroughly mixed with the fuel before deflagrating, or thoroughly and suddenly mixed with it during the deflagrating, as occurs in explosions which will be mentioned in the following part of this paper; excepting some cases which do not require describing in this paper.

Nitre melts when heated hot enough to appear reddish in the dark; and when exposed to a higher temperature, it effervesces by the escaping of its oxygen, and also by the escaping of its nitrogen when its effervescing continues long: and if when only melted, or when effervescing before it has effervesced much, it is poured on water, it produces crackling, and the chief of it is thrown from the water by the sudden generating of aeriform fluid: which crackling seems to me not powerful enough to be called explosion; though perhaps some

chemists so called it. When nitre under only atmospheric pressure, is exposed to a high temperature, it is prevented from having its temperature raised above a red heat by the evolving of its oxygen; somewhat as water is prevented by its evolving steam, from having its temperature raised above 212°: though somewhat proportionally as the quantities of the gases of the nitre are expelled by heat, the resulting potassous residuum permits its temperature to be raised higher. By heating nitre till so much of its gases escapes that its residuum will not effervesce at a yellow heat, and then pouring it on water, it commonly does not produce crackling nor rapid boiling till it cools to dark red, when it produces rapid boiling, but nothing like explosion. Hot nitre burns rapidly such fuel as wood, and before the nitre exhausts its power of burning, it generates caloric enough to raise the temperature of its remaining potassous product, to a white heat; and such product when bright white hot and effervescing a little or boiling, by undergoing mixing with hot water, produces more violent explosion than gunpowder produces by burning when confined as it usually is when stored: though this suggests that nitre may produce explosions nearly this way in burning buildings, this theme needs discussing much further. Proof was given in some instances, that no water was undergoing putting upon the building at the time of the explosion; but I am not aware of complete proof that water or watery liquid was not in or under the building at the time of any explosion which I attempt to explain nearly in this way; modified by the properties of the materials which produce explosion: hot nitre has so great power of burning organic substances, that generally a cargo and bottom of a vessel will not prevent melted nitre from burning and flowing downward so as to make a passage to the water beneath. Hot nitre and hot products of its combustion, at different temperatures, under prescribed circumstances, produce explosions by undergoing mixing with water or watery liquids. But attempts without skill, to produce intense explosions in this way, are apt to be frustrated by divers causes: thus, if nitre when with burning fuel, or its product when white hot, touches earthy substances, as common crucibles, it is apt to become so impure and cohesive, that when poured on water, it will in some instances remain quietly on the surface of the water, and in other instances, sink quietly to the bottom of the water, and after remaining quiet a few seconds without communicating its heat to the water very rapidly, it will then communicate its heat faster, but will then only produce rapid boiling: the potass of the nitre may be lost by its rapid evaporating at a white heat: some of the phenomena of these explosions can not be as well observed by using a large quantity of nitre at a time, as by using only a small quantity: and such a small quantity of it as an ounce, may cool so much by exposure to the air two seconds while moving it from the fire to the water, as to prevent its producing explosion; and if water is poured on the nitre or its remaining product while in the fire, some of the phenomena cannot be seen: if the heating of the nitre is not extended far enough, and it with its rapidly burning fuel, is poured on water, such

a small quantity as an ounce, is apt to remain a second or more without sinking into the water and without producing rapid boiling, after which, by the explosive action of a small part of the nitre or its melted product, the rest is thrown from the water; in other instances it cools without action violent enough to throw any of it from the water. A hessian crucible may be used in expelling a large portion of the gases from nitre, without heating the crucible so as to dissolve it much; by heating its upper part hot enough to melt some of the nitre which the crucible may contain, and letting its lower part remain rather less heated than its upper part, and putting a little wheat flour or small pieces of charcoal or anthracite or saw-dust of wood, on the nitre, and igniting the fuel, and adding such fuel in small parcels as it burns and raising the temperature till the burning moderates at a light red heat: after which, the remaining product of said combustion while warm, may be put in a thick forged iron crucible at a bright white heat, and as soon as said product can be heated white hot, and while effervescing a little or boiling, it may be quickly poured on water which has a temperature of about 130°, or the crucible may be put in the water while pouring; which will produce violent explosion. Either porcelain, hessian or forged iron crucibles will answer imperfectly for both first and second heating. Moreover, I produced explosions in a way so differing from said process as to expel gases from the nitre by heat, without putting fuel in contact with the nitre: and I produced explosion by mixing such hot pyrogenous product of nitre with cold, and also with boiling water: and I also produced explosion by continuing the deflagrating only till the product could have its temperature raised to a yellow heat, and then while effervescing, mixing it with water. Somewhat proportionally as the temperature of the melted pyrogenous product of nitre, and the temperature of the water, are higher, the more violent the explosion is apt to be, if any; though producing explosion with the product of nitre at a bright white heat, and water at near its boiling temperature, is difficult. Perhaps I can not do better in attempting to give some idea of the violence of explosions so made, than to state that in violent explosion under some circumstances, the hessian crucible which I used, was nearly all broken by the explosion into pieces not larger than a grain of sand.

In burning common fuel with nitre, some of the gases escape, while some carbon of the fuel combines with oxygen and potass of the nitre, forming carbonate of potass; yet such burning operation in a crucible, does not so saturate the remaining potass with carbon, as to cause it to operate exactly as common carbonate of potass does: thus, when the purest commercial carbonate of potass is quickly heated white hot in a porcelain or forged iron crucible, and poured on water, rapid boiling commences immediately and continues a second or more till explosion occurs; though with the carbonate of potass at a rather lower temperature when poured, the explosion occurs before the rapid boiling continues so long: but said pyrogenous product of nitre generally does not produce any rapid boiling before its explosion, though it sometimes remains quietly in the water a second or more before its

explosion: though in some trials without explosion, after such pyrogenous product of nitre remains at the bottom of the water till it is only red hot, some of it rises in globules and floats on the water; and commercial carbonate of potass about as frequently so rises.

In burning buildings, nitre is heated chiefly by contact with burning fuel, and when heated merely in this way, the fuel so rapidly and completely abstracts the oxygen from the nitre as to leave its potassium free, which dissipates at the temperature produced by the deflagration of a large mass of nitre with such combustible substances as dry wood, so that no considerable residuum or product of the nitre remains liquid at a yellow heat: the highest temperature which the liquid so produced, acquires before dissipating, is only a little above the lowest temperature at which it will produce explosion by undergoing mixing with water. And in the deflagration of nitre with materials as combustible as dry wood, the nitre decomposes and dissipates so rapidly, that, unless something facilitates mixing the nitre, the caloric so generated does not have time enough to penetrate the nitre so as to give much of it as high temperature as it might in a longer time. My mixing water with such deflagrating mass, produced very small explosion in some trials, and in other trials it did not produce any explosion. Anthracite burns slowly enough with nitre to permit a large mass of the remaining product of their combustion, to acquire nearly a uniform temperature: which I proved by putting some burning anthracite in a large hessian crucible containing nitre, whereby the nitre was heated only by the anthracite in the crucible, and when the product of their combustion had acquired its maximum temperature, I poured water on it, which produced mediocral explosion; not as violent as those produced by pouring white hot pyrogenous product of nitre, on water. I anticipate my readers inquiring whether any impurity in nitre increases the probability of its producing explosion. The chief saline impurity in nitre is culinary salt, which in the modern nomenclature of chemistry, is called chloride of sodium. Heating this salt quickly, and, as soon as it acquires a bright white heat and while effervescing a little or boiling, pouring it on water at the temperature of 150°, commonly produces violent explosion: with water at higher temperatures, explosions are produced with more difficulty. When chloride of sodium which is at a yellow heat and without any effervescing, is poured on water at 150°, the chloride commonly sinks to the bottom of the water if the water is only a few inches deep, and without producing rapid boiling, remains there till it is only red hot, when it rises in globules to the surface of the water, and remains on the surface of the water without communicating its heat to the water rapidly till it cools so as to appear reddish only in the dark, and it next produces rapid boiling without explosion: somewhat proportionally as either the temperature of the chloride of sodium when poured, or the temperature of the water, is higher, the chloride remains in the water longer before floating. By using cool water for receiving the hot chloride of sodium, explosions are easily made. Under some circumstances, such portions of chloride of sodium as often

occur in commercial nitre, cause explosions to be more violent than they would be without the chloride of sodium, especially with large masses: thus, in nitre's deflagrating with quite combustible substances, the rapidity of the deflagrating is diminished by such impurity, and consequently the caloric has more time for penetrating the nitre, and a larger quantity of the product of their deflagration exists at some instant in such a state that it will produce explosion by undergoing mixing with water, than would exist at any instant without the chloride of sodium: I put a little burning charcoal in a wooden cup a foot deep, and put on this fire, nitre which had chloride of sodium mixed with it, and when I guessed the nitre had nearly exhausted its power of deflagrating, I poured water into the cup, which produced stronger explosion than occurred in experiments without chloride of sodium; and explosion more generally occurred in experiments with, than in experiments without chloride of sodium.

The above statements seem not sufficient to enable a person to deduce a correct theory of the acting of the melted substance and water on each other in such exploding; therefore I add, that heating quickly the purest commercial caustic potass, white hot, and immediately while effervescing or boiling, mixing it with warm or hot water, produces violent explosion: and so making explosions with this material, is not as laborious as making the same kind of explosions by nitre: other substances generate explosions in the same way: pouring antimony when bright white hot, on warm water, produces violent explosion: and pouring either lead, tin or bismuth when so hot as to evaporate rapidly, on warm water, commonly produces less violent explosion. When a metal so generates explosion, the acting of the metal and water on each other, reduces the metal to powder. Substances are much more apt to generate explosion by undergoing pouring upon water while perfectly melted, than by undergoing pouring while cohesive. The difference between the state of materials which generates violent explosion, and that which generates no explosion, may be very small; but the materials may be in such states as to generate explosions of great varieties of force: a small explosion may result from only a part of a mass being in a state adapted to generate explosion: when the explosion occurs as soon as the melted material reaches the surface of the water, the chief of this material is commonly thrown from the water, and thereby prevented from mixing with the water so as to do much in generating explosion; this is more apt to occur with cold, than with warm or hot water: all materials do not require the same temperature of the water for generating explosions: explosions generated by hot water, are commonly rather more violent than those generated by cold water: in a large portion of the cases of violent explosion, the melted material sinks into the water quietly and remains quietly at the bottom of the water a second or more before the explosion occurs; such delay of the explosion is more apt to occur somewhat proportionally as the temperature of the water is higher.

Substances which require very high temperatures to generate vio-

lent explosions by contact with water, and do not like nitre, intensate fire, commonly are not heated hot enough in large quantities by the burning of buildings which contain them, to generate violent explosions: moreover, at the fire at Battery wharf in Boston, I observed small explosions generated by water's touching culinary salt; some of which I estimated to be about one-thousandth part as large as said explosion generated by nitre in the schooner *Sarah*. Like nitrate of potass, nitrate of soda deflagrates with combustible substances; and its hot effervescing product of deflagration, and also its residuum left by expelling gases from this nitrate by heat without its touching fuel, generates explosion by contact with water: the powers of these two nitrates to generate explosions in this way, under such circumstances as are apt to occur, seem to me nearly equal: one small difference is, that in heating them under some circumstances, rather less of the soda remains undissipated which may generate explosion; and in such case, it is less apt than nitrate of potass, to generate large explosion. The *Quarterly Review* published at London in December, 1854, implies that nitrate of soda generated explosion in the burning of Sissons' warehouse at Gateshead. Chlorate of potass deflagrates with combustible substances faster than nitre does: and its yellow hot effervescing or boiling product of deflagration, and also its residuum left by expelling its oxygen by heat without its touching fuel, generate explosion by contact with water: this substance dissipates before it becomes white hot, and does not remain liquid and hot enough to generate as violent explosion as is generated by the white hot pyrogenous product of nitre: though it can without producing all its power, generate explosions strong enough to demolish the strongest warehouses. While chlorate of potass is deflagrating with fuel, and before the chlorate nearly exhausts its power of deflagrating, water may be poured on it without producing explosion. The using of nitrate of soda and chlorate of potass, seems to be increasing, which is one cause of my mentioning their said powers of generating explosion.

At some vessels, nitre or its remaining pyrogenous product, seems to have acted with sea-water in generating explosion; which induces me to mention that I put into a large hessian crucible which contained nitre, anthracite hot enough to burn with the nitre, whereby the nitre was heated solely by the anthracite in the crucible, and when the remaining product of this combustion had acquired its maximum temperature, I poured sea-water on it, which produced explosion. The published evidence relative to the explosions at Crocker and Warren's said store, implies that this store did not contain water at the time of the explosions there; and it proves that the cellar of this store contained molasses, and that the foundation walls of this building were nearly obliterated by the explosions; which proof and other causes, induce me to state that such product of nitre as generated explosion with water, did not in my experimenting generate any explosion by contact with either cold or warm molasses; also, when nitre was merely melted without effervescing, pouring it on either cold or warm molasses, did not produce explosion; but nitre hot enough to effervesce

rapidly and before it had effervesced long, by contact with either cold or hot molasses of different kinds, always generated explosion; which was not as violent as explosions made by pouring melted substances at bright white heat, on water. Proof was given that no water was undergoing putting on B. S. Woolley's said store at the time of the explosions there; but Woolley testified he believed the cellar of this store contained brandy: I therefore add, that pouring said rapidly effervescing residuum of nitre on the purest commercial alcohol, kindles it without explosion; but pouring it on a mixture of about one part alcohol with two water, produces explosion. Perhaps I should also add, that pouring such rapidly effervescing residuum on common or more dilute sulphuric acid, produces explosion. In my trials implied above, which produced explosions with molasses, with a mixture of alcohol with water, and with common or more dilute sulphuric acid, the nitre had not been heated sufficiently to generate explosion by contact with mere water. Some anhydrous liquids, and also some anhydrous powders, which do not generate any explosive action by undergoing slow heating, generate sufficient explosive action to produce an obtuse clap by contact with hot, effervescing nitre or its pyrogenous product.

New Gun-metal.

The cannons newly cast in Austria for the marine service, and from which so much is expected, are formed from a new alloy called *Aich* metal from the name of the inventor. It is composed of copper 600 parts; zinc, 382; iron, 18. Its tenacity is said to be excessive; it is easily forged and bored; when cold it may be bent considerably without breaking; its resistance is far greater than that of iron of the best quality.

This announcement makes us earnestly wish to learn the fate of the cannon of aluminium-bronze, which M. Christophe cast at his own expense, and which was so severely tried at Vincennes.—*Cosmos.*

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*Manufacture of Armor Plates.**

From the Mechanics' Magazine, April, 1862.

That the British Navy must be reconstructed by the substitution of armor-plated ships of war for its old wooden walls, is now universally admitted. It becomes, therefore, a most important question, what is the best method of manufacturing the armor plates? This subject was first brought under the consideration of the writer when the Thames Iron Works Company received the order for building the *Warrior*, and it became a question with the firm whether they should erect steam hammers for the purpose of forging, or increase the power of their mills for rolling the plates. At that period, after careful consideration, the conclusion was adopted, that the plan of hammering would produce the best results, and subsequent experience has, in

* Paper read by Captain J. Ford, at the Institution of Naval Architects, March 27th, 1862.

the opinion of the writer, fully borne out that view. That the best material for these plates is iron, appears to be established by all the experiments which have been made; many trials of plates of homogeneous metal, or steel of various descriptions, have shown that, although thin steel plates have resisted shot better than iron ones, when the thickness was increased beyond ¾-inch, there was visible inferiority, and the thicker plates altogether failed.

Two qualities of the iron appear to be of prime necessity—toughness and solidity. If the iron is hard and brittle, it is easily cracked and broken by the shot; if unsound, either from blisters or lamination arising from imperfect welding, the power of resistance is proportionately diminished. It has been conclusively proved that any given thickness of iron, if composed of layers of thin plates, has very little resisting power in comparison with the same thickness of solid plate; and a plate apparently solid, but imperfectly welded, exhibits the same weakness.

The process of rolling plates 4½ inches thick, has been described by the head of the eminent firm of Messrs. Brown & Co., of Sheffield, in a paper read by him at the Institution of Mechanical Engineers, Birmingham, as follows:—Bars, 12 inches broad, 1 inch thick, are first rolled; five of these are then piled and rolled into a rough slab; two of these slabs are rolled into a plate 1¼ inch thick; four of these plates are then piled and rolled into a plate 2½ inches thick; and, finally, four of these 2½-inch plates are piled and rolled into the finished plate. The hammered plates manufactured at the Thames Iron Works are made in the following manner:—Scrap iron of the best description is carefully selected and cleaned, piled, hammered into a bloom, and then rolled into bars 6 inches broad, 1 inch thick; these bars are cut up, piled, and again hammered into a slab; several of these slabs are put together, heated, and hammered to the form required, and this process being repeated, the plate goes on gradually increasing to the length required.

In the manufacture of the best hammered plates there is no mystery; it depends simply on the selection of the best material, and the employment of the most skilled and careful workmanship.

The writer confidently believes that scrap iron, rolled and hammered as before described, is decidedly the best material, and superior to any description of the puddled iron from which all the rolled plates are understood to be made. That the toughness of iron is dependent greatly upon the amount of working it undergoes, cannot be doubted. This working has already been given to a great extent to scrap iron, and the process of rolling it into the 6-inch bars, which are the raw material of the future plate, gives it a degree of toughness and fibre which it appears to retain through all the subsequent heating and hammering.

The tendency of hammering to harden, does not take away this toughness, and the process of annealing restores much of what is lost. Numerous experiments on single plates which have been fired at, and close observation in the drilling, planing, and bending of the large

quantities of plates which have been hammered in this manner, have shown that the brittleness which has been attributed to hammered iron is entirely avoided, and that the toughness of the iron is superior to that of the best rolled plates which have hitherto been produced. Solidity and freedom from blisters or lamination is unquestionably more certain in the hammering process; and when it is considered that, to produce a rolled plate, 160 thicknesses of iron must be perfectly welded at every point throughout the finished plate, under penalty of there being lamination, the frequent occurrence of this evil would seem to be inevitable; the presence of dirt between any two layers, or the failure to reach a welding heat in any part of the centre of the large masses which have to be dealt with, being certain to produce this fatal result.

It must also be remembered that, as the hammered plate is gradually built up of the slabs before described, a comparatively small portion of the mass requires to be placed in the furnace and heated at one time, while in the rolled plate the final pile, 10 inches in thickness, and weighing six or seven tons, must be brought to a welding heat at once, and the operation of rolling completed before this heat is lost. To obtain this heat throughout the mass without burning the edges most exposed to the fire, can hardly be counted upon as a uniform result, and when this has been accomplished, and delay in dragging it from the furnace, getting it to the rolls, forcing it between them, and completing the rolling process, will spoil it, and the loss even of a few moments, may be fatal to the success of the operation.

These difficulties of course increase with the thickness and weight of the plates; the foregoing observations are made with reference to plates $4\frac{1}{2}$ inches thick, such as are on the sides of the *Warrior* and her companions; but when, as in the case of the *Minotour* and her sister ships now building, the thickness of the plates is increased to $5\frac{1}{2}$ inches, it may well be doubted if these difficulties can be successfully overcome in the rolling process.

It will not perhaps be out of place to refer to the return made to an order of the House of Commons, dated May 17th, 1861, of the mode of manufacturing the armor plates of the *Warrior*, and three of her companion ships, and the number of plates condemned in the process of manufacture, with the reasons for their condemnation. The *Warrior's* plates, about 950 tons, were all hammered, and only five plates proved faulty in the process of manufacturing. Of the plates for the *Defence* and *Resistance*, together about 1200 tons, all but six were rolled; 45 were condemned for being blistered, laminated, or overheated; and of the plates for the *Black Prince*, 950 tons in all, of which above 100 tons were rolled, and the rest hammered, 10 rolled plates and 32 hammered plates were condemned. It is to be observed, however, that in the manufacture of the hammered plates for the *Black Prince*, the whole operation was performed under the hammer, and the process of rolling the initial bloom into 6-inch bars was omitted. It is understood that, in the hammered plates which have failed comparatively under trial, this preliminary rolling has not been adopt-

ed, and to this, to some extent, their failure to stand the test may be due.

The experiments made at Shoeburyness by the Plate Committee on plates of various thicknesses, and upon the *Warrior* and other targets, have not yet been reported on by the Committee, but it is understood by the writer, who, by the courtesy of the Committee, has had the opportunity of observing many of the experiments, that those manufactured as described at the Thames Iron Works have exhibited uniform and superior excellence, which has also been exemplified in all the trials of sample plates selected by the government officers, and fired at at Portsmouth.

The attempt has recently been made to effect a combination of the two processes of hammering and rolling; the slab 10 inches or thereabouts in thickness, being forged under the hammer, then heated *en masse*, and rolled in the same manner as the pile, forming the final process described for the rolled plate. To this the writer objects, that this plan involves the serious difficulties already adverted to as consequent on the heating and rolling of so large a mass. Thus far experiment confirms this opinion, as the plates manufactured in this manner have proved under trial greatly inferior both to the rolled plates and those hammered at the Thames Iron Works.

In the minor qualities of smoothness of surface and uniformity of thickness, it may be observed that the hammered plates are quite equal to the rolled, and with respect to cost of production up to the thickness of 4½ inches, the market price of hammered and rolled plates is the same; but if the thickness and weight be increased, the cost of rolling will, without doubt, be seriously enhanced, while that of hammering will remain but little, if at all, altered.

Influence of Silica on Fermentation.

M. Leuchs announces that silica precipitated from soluble glass gives rise to the alcoholic fermentation in a solution of sugar, especially if a little tartaric acid be added, and preserves this property in a durable way. Washing in water does not remove this property.—*Dingler's Polytechnisches Journal.*

Silvering Glass, &c. J. Cimeg, Great Portland Street, London. Dated March 13, 1861.

From the London Chemical News, No. 103.

For the purpose of depositing a bright film of metallic silver upon glass and other surfaces, the inventor employs ammonio-nitrate of silver, to which he adds a solution of Rochelle salt (tartrate of potash and soda). The silver is deposited by the action of this reducing agent at the ordinary temperature of the air, no external aid being required for the purpose of facilitating the production of the metallic film. The thin layer of silver so formed may be backed and strengthened by an electro-deposit of copper, or other cheap metal. This

method of operating is also useful for the coating of small objects prior to electrotyping, which, being non-conductors of electricity, require to have a superficial conducting layer imparted to them. By commencing with a plate of glass having polished and dull surfaces, an ornamental device may be executed.

This process of depositing bright metallic silver upon glass was experimentally illustrated by Professor Faraday at one of his Friday evening lectures at the Royal Institution some years since. The brilliant lustre of the truly "silvered" surfaces was much admired.

For the Journal of the Franklin Institute.

Strength of Cast Iron and Timber Pillars: A series of Tables showing the Breaking Weight of Cast Iron, Dantzic Oak, and Red Deal Pillars. By Wm. Bryson, Civ. Eng.

(Continued from vol. xliii., page 273.)

Solid Uniform Cylindrical Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $w = 6{\cdot}71\frac{D^4}{L^2}$.	Value of w.	Value of c.	Calculated breaking weight in tons from formula, $r = \frac{wc}{w+\frac{1}{2}c}$.	Strength per sq. inch of section in tons.
18	8	27		84·82	173·46	68·46	1·36
19	"	28·5		76·13	"	64·03	1·27
20	"	30		68·71	"	59·95	1·19
21	"	31·5		62·32	"	55·89	1·11
22	"	33		56·78	"	52·70	1·04
23	"	34·5		51·95	"	49·50	0·98
24	"	36		47·71	"	46·54	0·92
25	"	37·5		43·97	"	43·81	0·87
26	"	39	40·65				0·80
27	"	40·5	37·70				0·75
28	"	42	35·05				0·69
29	"	43·5	32·68				0·65
30	"	45	30·53				0·60

Solid Uniform Cylindrical Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

			$w = 4{\cdot}79\frac{D^4}{L^2}$.				
18	8	27		60·55	147·78	52·21	1·03
19	"	28·5		54·34	"	48·61	0 96
20	"	30		49 04	"	45·33	0·90
21	"	31·5		44·48	"	42.32	0·84
22	"	33		40·53	"	39·57	0·78
23	"	34·5		37·08	"	37·04	0·73
24	"	36	34·06				0·67
25	"	37·5	31·39				0·62
26	"	39	29·02				0·57
27	"	40·5	26·91				0·53
28	"	42	25·02				0·49
29	"	43·5	23·32				0·46
30	"	45	21·79				0·43

Table comparing the strength of hollow uniform cylindrical pillars of cast iron having both ends rounded or irregularly fixed, with pillars of the same dimensions having both ends flat and firmly fixed; deduced from the mean results of the preceding tables, as computed by Mr. Hodgkinson's formulæ (three in each case); also, showing the mean strength per square inch of sectional area, and mean ratio of strength.

Hollow Uniform Cylindrical Pillars of Cast Iron, with Both Ends Rounded or Irregularly Fixed, and with Both Ends Flat and Firmly Fixed.

Length or height of Pillar in feet.	External diameter in inches.	Internal diameter in inches.	Number of diameters contained in the length or height.	Mean Breaking Weight of Pillar, and per square inch of section, in tons.				Ratio of strength.
				Rounded Ends.		Flat Ends.		
				Pillar.	Per square inch.	Pillar.	Per square inch.	
6	8	6	9	547·73	24·90	790·27	35·93	1·44
7·5	"	"	11·25	446·99	20·32	705·07	32·05	1·57
8	"	"	12			678·30	30·84	
9	"	"	13·5	369·00	16·77	627·58	28·53	1·70
10	"	"	15			580·76	26·40	
10·5	"	"	15·75	308·54	14·02	558·81	25·40	1·81
11	"	"	16·5			537·82	24·45	
11·5	"	"	17·25			517·77	23·53	
12	"	"	18	256·05	11·64	498·62	22·67	1·94
12·5	"	"	18·75			480·35	21·83	
14	"	"	21	200·12	9·09	430·45	19·56	2·15
16	"	"	24	159·48	7·24	374·11	17·00	2·34
18	"	"	27	130·54	5·93	327·45	14·88	2·50
20	"	"	30	109·12	4·95	288·64	13·12	2·64
22	"	"	33	92·80	4·21	252·16	11·46	2·71
24	"	"	36	80·05	3·63	217·94	9·90	2·72
26	"	"	39	69·86	3·17	190·57	8·66	2·72
28	"	"	42	61·59	2·79	168·30	7·69	2·73
30	"	"	45	54·77	2·48	149·92	6·81	2·73

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	External diameter in inches.	Internal diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $w = 46{\cdot}65 \frac{p^{3{\cdot}55} - d^{3{\cdot}55}}{l^{1{\cdot}7}}$	Value of w.	Value of c.	Calculated breaking weight in tons from formula, $T = \frac{w\,c}{w + \frac{2}{3}c}$.	Calculated breaking weight per square inch of section.
6	8	6	9		2280·52	1077·56	795·61	36·18
8	"	"	12		1398·42	"	682·90	31·05
10	"	"	15		956·95	"	584·19	26·56
12	"	"	18		701·92	"	500·86	22·77
14	"	"	21		540·10	"	431·65	19·62
16	"	"	24		430·42	"	374·46	17·01
18	"	"	27		352·32	"	327·14	14·87
20	"	"	30		294·53	"	287·81	13·08
22	"	"	33	250·47				11·39
24	"	"	36	216·04				9·82
26	"	"	39	188·55				8·57
28	"	"	42	166·23				7·55
30	"	"	45	147·83				6·72

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	External diameter in inches.	Internal diameter in inches.	Number of diameters contained in the length or height.	Value of w in tons from formula $w = 44{\cdot}34\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$	Value of c.	Calculated breaking weight in tons from formula, $T = \frac{w\,c}{w + \frac{1}{2}c}$.	Strength per sq. inch of section in tons.
6	8	6	9	2167·88	1077·56	784·94	35·69
8	"	"	12	1329·17		670·11	30·47
10	"	"	15	909 57		570·58	25·94
12	"	"	18	667·16		487·28	22·15
14	"	"	21	513·35		418·58	19·03
16	"	"	24	409·10		362·14	16·46
18	"	"	27	334·87		315·68	14·35
20	"	"	30	279·94		277·22	12·60
6	"	6·50	9	1766·70	837·34	617·74	36·16
8	"	"	12	1083·34		530·06	31·03
10	"	"	15	741·34		453·32	26·54
12	"	"	18	543·77		388·57	22·75
14	"	"	21	418·41		334·81	19 60
16	"	"	24	333·44		290·39	17·00
18	"	"	27	272 94		253·67	14·85
20	"	"	30	228·17		223·15	13·06
6	"	6·75	9	1534·26	709·55	526·82	36·38
8	"	"	12	940·81		453·20	31·29
10	"	"	15	643 80		388·45	26·82
12	"	"	18	472·23		333 60	23·03
14	"	"	21	363·36		287·90	19 88
16	"	"	24	289·57		250·04	17·26
18	"	"	27	237·03		218·65	15·10
20	"	"	30	198·21		192·56	13·29
6	"	7·00	9	1278·90	577·26	431·26	36·60
8	"	"	12	784·22		371·93	31·57
10	"	"	15	536·65		319·50	27·12
12	"	"	18	393·63		274·90	23·33
14	"	"	21	302 88		237·61	20·17
16	"	"	24	241·37		206·63	17·54
18	"	"	27	197·58		180·89	15·35
20	"	"	30	165·17		159·41	13·53
6	"	7·25	9	999·13	440·16	330·84	36·84
8	"	"	12	612·66		286·03	31·85
10	"	"	15	419·25		246·25	27·42
12	"	"	18	307·52		212·27	23 63
14	"	"	21	236·62		183·77	20·46
16	"	"	24	188·57		160·02	17·81
18	"	"	27	154·35		140·23	15·61
20	"	"	30	129·03		123·69	13·77

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	External diameter in inches.	Internal diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 13\frac{D^{3\cdot76} - d^{3\cdot76}}{L^{1\cdot7}}$	Value of w.	Value of c.	Calculated breaking weight in tons from formula, $T = \frac{w\,c}{w + \frac{3}{4}c}$,	Strength per sq. inch of section in tons.
6	8	6	9		1016·90	1077·56	600·16	
8	"	"	12		623·01	"	469·07	21·33
10	"	"	15		426 33	"	372·13	16·92
12	"	"	18		312·71	"	300·62	
6	"	6·50	9		833·06	837·04	477·33	27·94
8	"	"	12		510·83	"	375·53	21·98
10	"	"	15		349·57	"	299·38	17·52
12	"	"	18		256·40	"	242·73	14·21
14	"	"	21	197·29				11·55
16	"	"	24	157·22				9·20
18	"	"	27	128·70				7·53
20	"	"	30	107·59				6·29
6	"	6·75	9		725·69	709·55	409·36	28·27
8	"	"	12		444·99	"	323·12	22·31
10	"	"	15		304·51	"	258·24	17·83
12	"	"	18		223·36	"	209·77	14·48
14	"	"	21	171·86				11·86
16	"	"	24	136·96				9·45
18	"	"	27	112·11				7·74
20	"	"	30	93·72				6·47
6	"	7·00	9		606·76	577·26	336·88	28·59
8	"	"	12		372·06	"	266·80	22·64
10	"	"	15		254·61	"	213·76	18·14
12	"	"	18		186·75	"	173·96	14·76
14	"	"	21	143 70				12·19
16	"	"	24	114·51				9·72
18	"	"	27	93 73				7·95
20	"	"	30	78·36				6·65
6	"	7·25	9		475·53	440·16	259·80	28 93
8	"	"	12		291·59	"	206·44	22·98
10	"	"	15		199·54	"	165·82	18·46
12	"	"	18		146·36	"	135 20	15·05
14	"	"	21		112·62	"	111·96	12·46
16	"	"	24	89 75				9·99
18	"	"	27	73 46				8·18
20	"	"	30	61·41				6·83

Tables showing the Strength of Hollow Uniform Cylindrical Pillars of Cast Iron, having both ends rounded or irregularly fixed, and pillars having both ends flat and firmly fixed; deduced from the results of the late Mr. Eaton Hodgkinson's experiments on the resistance of hollow cylinders of cast iron to a force of compression. Low Moor Iron, No. 3.

Hollow Uniform Cylindrical Pillars of Cast Iron with Both Ends Rounded or Irregularly Fixed—"The ends having hemispherical caps on them, that the compressive force might act through the axis of the pillar."

Length or height of Pillar in feet.	External diameter in inches.	Internal diameter in inches.	Number of diameters contained in the length or height.	Breaking weight of pillar in tons.	Strength per sq. in. of section in tons.
7·5625	1·78	1·21	50 98	2·49	1·86
"	1·74	1·187	52·15	2·54	2·00
"	2·01	1 415	45·14	3·73	2 32
"	2·33	1·70	38 94	6·73	3·37
"	2 23	1·54	40·69	5·53	2·70
"	2·24	1·735	40·51	5·95	3·77
"	2·24	1·58	40·51	6·21	3·13
"	2·49	1·89	36·44	8·86	4·29
"	2·47	1·98	36·74	8·48	4·95
"	2·46	1·855	36·89	8·54	4·16
"	2·73	2·17	33·24	10·69	4·96
"	2·74	2·155	33·12	12·44	5·53
"	3 01	2·48	30·14	11·92	5·21
"	3·36	2·823	27 00	18·29	7·00
"	3·36	2·63	27·00	22·53	6·56
4 75	1·78	1·21	32·02	6·11	4·56
"	2·31	1·67	24·67	16·24	5·34
2·5833	1·85	1·36	16·75	15·07	12·20
Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.					
7·3958	1·78	1·21	49·85	7·96	5 94
"	1·74	1·187	51·00	7·45	5·86
7·5625	1·76	1·18	51·56	7·47	5·58
"	1·75	1·11	51·85	9·35	6·50
7·3958	2 04	1·46	43·50	14·47	9·07
7·5625	2·01	1·368	45·14	13·74	8·07
7·3958	2·01	1·415	44·15	12 65	7·90
7·4833	1·99	1·31	45·12	12·08	6·85
7·3958	2·23	1·54	39·79	18·11	8·86
2·5208	1·26	·767	24·00	15·03	19·15
"	1·26	·781	24·00	14 67	19·11
2·1666	1·25	·768	20·79	15·75	20·63
"	1·17	·752	22·22	13·92	22·07
1·9166	1·16	·7705	19·82	13·56	22·97
1·6805	1·21	·77	16·66	18·63	27·24
"	1·14	·805	17·68	12·11	23·67
1·4166	1·15	·91	14·78	11·38	29·32
1·3333	1·15	·92	13·92	11·20	29·97
1·2604	1·16	·932	13·03	11·93	31·85
"	1·08	·77	14·00	12·11	26·89
1·1667	1·15	·792	12·17	16·64	30·48
0·7333	1·13	·91	7·78	15·19	43·11

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	External diameter. Inch.	Internal diameter. Inch.	Number of diameters contained in the length or height.	Value of w in tons from formula, $w = 44{\cdot}34 \frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{l^{1{\cdot}7}}$.	Value of e.	Calculated breaking weight in tons from formula, $Y = \frac{w e}{w + \frac{2}{3} e}$.	Strength per square inch of section in tons.
2·5208	1·26	·767	24·007	17·32	38·47	14·43	18 39
2·5208	1·26	·781	24·007	17·08	37·63	14·19	18 48
2·1666	1·25	·768	20·799	21·63	37·44	16·29	21 33
2·1666	1·17	·752	22·222	16 46	30·93	12·84	20·35
1·9166	1·16	·7705	19·826	19·03	28·94	13·52	22·90
1·6805	1·21	·77	16·666	28 83	33·54	17·91	26·18
1·6805	1·14	·805	17·689	20·71	25 08	13·14	25·69
1·4166	1·15	·91	14·781	22·73	19·03	11·69	30·11
1·3333	1·15	·92	13·921	24·43	18·32	11·72	31·36
1·2604	1·16	·932	13 038	27·36	18·36	12·21	32 61
1·2604	1·08	·77	14 004	27·48	22·07	13·77	30·59
1·1667	1·15	·792	12·174	41·03	26·76	17·97	32·91
0·7333	1·13	·91	7·787	59·37	17·27	14·17	40·22

Table comparing the Strength of Hollow Uniform Cylindrical Pillars of Cast Iron having Both Ends Rounded or Irregularly Fixed, with Pillars having Both Ends Flat and Firmly Fixed; deduced from the results of the late Mr. Hodgkinson's experiments.

Length or height of pillar in inches.	External diameter in inches.	Internal diameter in inches.	Number of diameters contained in the length or height.	Rounded Ends. Ends having hemispherical caps on them, that the compressing force might act through the axis of pillar. Break. weight of pillar in tons.	Rounded Ends. Break. weight per sq. inch of section in tons.	Flat Ends. Ends turned flat and perpendicular to the sides. Break. weight of pillar in tons.	Flat Ends. Break. weight per sq. inch of section in tons.	Ratio of strength.
90·75	1·78	1·21	50·98	2·4933	1·86			
88·75	1·78	1·21	49 85			7·9642	5·94	3·19
90·75	1·74	1·187	52·15	2·5495	2·00			
88·75	1·74	1·187	51·00			7·4575	5·86	2·92
90·75	2·01	1·415	45·14	3·7308	2·32			
88·75	2·01	1·415	44·15			12·6575	7·90	3·39
90·75	2·01	1·368	45·14			13·7450	8·07	
90·75	2·23	1·54	40·69	5·5308	2·70			
88·75	2·23	1·54	39·79			18·1111	8·86	3·27
90 75	2·73	2·17	33·24	10·6977	4·96			
90·75	3·01	2·48	30·14	11·9227	5·21			
90·75	3 36	2·63	27 00	22·5343	6·56			
57·00	1·78	1·21	32·02	6·1129	4·56			
57·00	2·31	1·67	24·67	16·2419	5·34			
30·24	1·26	0·767	24·00			15·0352	19·15	
31·00	1·85	1·36	16·75	15·0727	12·20			
20·166	1·21	0·77	16·66			18·6388	27·24	
8·7996	1·13	0·91	7·78			15·1950	43·11	

Mr. Hodgkinson remarks, "In hollow pillars of greater diameter at one end than the other, or in the middle than at the ends, it was not found that any additional strength was obtained over that of uniform cylindrical pillars; on the other hand, the strength of these seemed to be greater; with respect to this, however, the conclusions were not very decisive."

As solid pintles of cast iron were employed in the construction of the Pemberton Mill, Lawrence, Mass., I here introduce the following calculations for short solid pillars, with the intention of referring to them again.

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar.	Diameter in inches.	Number of diameters contained in the length or height.	Value of w in tons from formula, $w = 44{\cdot}16 \frac{D^{3{\cdot}55}}{l^{1{\cdot}7}}$.	Value of c.	Calculated breaking weight in tons from formula, $T = \frac{wc}{w + \frac{4}{9}c}$.	Strength per sq. inch of section in tons.
Foot.						
1	3	4	2181·76	346·36	309 50	43·81
1·25	"	5	1493·03	"	295·02	41·73
1·48958	"	5 958	1108·16	"	280·58	39 69

This last pillar is of the same dimensions as the pintles referred to in the Pemberton Mill, and the following calculation is for the same with rounded ends or irregularly fixed.—

Solid Uniform Cylindrical Pillar of Cast Iron, Both Ends being Rounded or Irregularly Fixed.

			$w = 14{\cdot}9 \frac{D^{3{\cdot}76}}{l^{1{\cdot}7}}$.			
1·48958	3	5·958	470·93	346·36	223·22	31·57

(To be Continued.)

Apparatus of M. Schau for avoiding Scale in Boilers.

The apparatus of M. Schau consists of a cylinder closed on top and connected with the boiler by a short tube. Into this cylinder the feed water is thrown in a shower, so that the heat of the steam brings it instantaneously to the boiling temperature before it reaches the boiler. This rise of temperature precipitates the solid matters which are deposited in the cylinder, while the water in a purified state goes to the boiler. An Austrian locomotive provided with this apparatus ran over 5500 miles (8880 kilom.); during which about 45 lbs. of a soft material like soap was deposited in the cylinder, while the boiler was kept perfectly clean. This result is the more remarkable, since at the beginning of the experiment it was coated, to a thickness of $\frac{3}{10}$ths of an inch, with a solid crust, which completely disappeared during the experiment.

M. Engerth, State-Counsellor, who presided at the meeting of Austrian Engineers, to which the above was communicated, remarked that it was probably his experiments on locomotives which suggested to M. Schau the first idea of his simple and ingenious apparatus. It is known in fact that when the feed water returns to the tender after being strongly heated, there is formed in that reservoir a considerable deposit, whilst the boiler itself is comparatively free.—*Zeitschrift der Osterreichischen Ingenieur-vereins.*

The Poisonous Effects of Carbonic Oxide. By H. LETHEBY, M. B., M. A., Ph. D., &c., Professor of Chemistry and Toxicology in the Medical College of the London Hospital.

From the London Chemical News, No. 124.

A good deal of misapprehension seems to prevail respecting the poisonous action of carbonic oxide. On the one hand, accidents have somewhat recently occurred where in all probability the effects of the gas were entirely overlooked; and on the other, fatal consequences have been unjustly attributed to it. Some of this confusion is due to the circumstance that our standard works on poisons and medical jurisprudence have either omitted the subject entirely, or have discussed it in very meagre language. The recent catastrophe at the Hartley colliery, and the remarks which have been published respecting the supposed influence of the gas in causing the death of the men, have created an opportunity for a re-examination of this question.

Carbonic oxide was discovered by Priestley long before the close of the last century; and in 1802, Clement and Desormes, at the instance of Guyton Morveau, undertook a careful examination of its properties. They not only proved its chemical nature, but they also ascertained that it was a poisonous gas. Birds put into it dropped dead before they could be taken out; and when the experimenters themselves attempted to breathe it, they were attacked with giddiness and faintness. This experiment was repeated by Sir Humphrey Davy in 1810, who says that when he took three inspirations of it, mixed with about one-fourth of common air, the effect was a temporary loss of sensation, which was succeeded by giddiness, sickness, acute pains in different parts of the body, and extreme debility; some days elapsed before he entirely recovered. It is, he says, fatal to animal life.

About the same time, the researches of Nysten demonstrated that the gas was capable of producing great disturbance of the system when injected into the veins; and although he concluded that the effects were of a mechanical nature, yet the accounts which he has given prove that the gas is a dangerous poison.

Later still, in 1814, the two assistants of Mr. Higgins, of Dublin, made experiments with it upon themselves, and in one case, that of Mr. Wilter, with almost a fatal result. Having exhausted the lungs of air, he inhaled the pure gas three or four times, and was suddenly deprived of sense and volition; he fell upon the floor, and continued in a state of perfect insensibility, resembling apoplexy, and with a pulse nearly extinct. Various restorative means were employed, but without success, until they resorted to the use of oxygen, which was forced into his lungs, and then his life was restored; but he was affected with convulsive agitation of the body for the rest of the day. He suffered also from violent headache, stupor, and a quick, irregular pulse. Even after mental recovery, he suffered from giddiness, blindness, nausea, alternate heats and chills, and irresistible sleep. The other gentleman, after inhaling the gas two or three times, was seized with giddiness, tremor, and incipient insensibility. These effects were

followed by languor, weakness, and headache of some hours duration.

Since those experiments were made, others of a more extended character were instituted by Tourdes and by Leblanc. Tourdes found that rabbits were killed in seven minutes when they were put into a mixture of one part of the gas with seven of atmospheric air. A fifteenth part of the gas in common air killed them in twenty-three minutes; and a thirtieth part in thirty-seven minutes. Leblanc's experiments were made in conjunction with Dumas, and he ascertained that one per cent. of the gas in atmospheric air would kill a small dog in a minute and a half, and that birds were killed immediately in a mixture containing five per cent. of it.

Very recently, I have myself ascertained that air containing only 0·5 per centum of the gas will kill small birds in about three minutes; and that a mixture containing one per cent. of the gas will kill in about half this time. An atmosphere having two per cent. of the gas will render a guinea-pig insensible in two minutes; and in all these cases the effects are the same. The animals show no sign of pain; they fall insensible, and either die at once with a slight flutter, hardly amounting to convulsion, or they gradually sleep away as if in profound coma. The post mortem appearances are not very striking: the blood is a little redder than usual, the auricles are somewhat gorged with blood, and the brain is a little congested. In birds there is nearly always effusion of blood in the brain, and it may be seen through the transparent calvaria by merely stripping off the scalp after death.

Accident has also demonstrated how injurious the gas is even to the human subject. For many years past attempts have been made to promote the use of water-gas as an agent of illumination. The gas sometimes contains as much as thirty-four per cent. of carbonic oxide. It is obtained by passing steam over red-hot charcoal; and as the steam is decomposed by the ignited carbon, the hydrogen is set free, and carbonic oxide, with carbonic acid, is produced. Patents for this process of manufacturing gas date as far back as the year 1810, and they have at various times been put into operation in this country and on the Continent. Sellique, in 1840, obtained permission to use the gas in the towns of Dijon, Strasburg, Antwerp, and two of the faubourgs of Paris and Lyons. At Strasburg an accident occurred which put a stop to its use. The gas escaped from the pipes into a baker's shop, and was fatal to several persons; and not long after an aëronaut, named Delcourt, incautiously used the gas for inflating his balloon. He was made insensible in the car, and those who approached the balloon to give him assistance fainted and fell likewise. The use of the gas has, therefore, been interdicted on the Continent.

Another source of danger from it is in the combustion of carbon. It is found in the neighborhood of brick-kilns and furnaces. The gases discharged from the latter contain it in large proportion. Iron furnaces produce it to the extent of from twenty-five to thirty-two

per cent., and copper furnaces from thirteen to nineteen per cent. In the year 1846, M. Adrien Chenol was anxious to ascertain the properties of the gases yielded by his process of smelting zinc ores with carbon; and, not having a suitable instrument for collecting the gases, he attempted to draw them out of the furnace by means of a pipette. Some of the gas was thus inhaled, and he fell immediately, as if he had been stunned; the eyes were turned back in the orbits, the skin was discolored, the veins were swollen, and presented a black tint under the skin; there were violent pains in the chest, and the brain felt powerfully oppressed. After removal to the open air, and the application of restoratives, sensibility gradually returned, but the internal pains were still severe, and there was a feeling of suffocation. For several days he felt depressed and languid; the digestion was bad; sleep was obstinate and heavy, and it was frequently disturbed by cramps in the knees and toes. Even for months afterwards there was a morbidly excited state of the nervous system.

In a more diluted condition, the gas is still able to exert an injurious action, and it is very probable that the singular catastrophe which happened at Clayton Moor, near Whitehaven, in the summer of 1857, was caused by the diffusion into the air of carbonic oxide from the neighboring iron furnaces. There is a row of cottages near to these furnaces, where, in the month of June, 1857, a number of persons were suddenly seized with insensibility, which soon passed in some cases into coma and death. About thirty persons were thus attacked, and six of them died. The effects were attributed at the time to the escape of sulphuretted hydrogen from the slag on which the cottages were built; but it is more probable they were caused by the oxide of carbon from the furnaces.

Lastly, it is worthy of remark that very recently Boussingault has noticed that the leaves of aquatic plants give off carbonic oxide and marsh gas when under the influence of solar light; and he asks whether this gas so produced may not be concerned in the unhealthiness of marsh districts.

A more complete acquaintance with the effects of this poison is a great desideratum, although enough is known to indicate its general mode of action, and to furnish evidence for its discovery.—*Lancet.*

Ratan Deep-Sea Electric Telegraph Cable.

From the Journal of the Society of Arts, No. 490.

Mr. C. S. Duncan, the inventor, in adopting the Ratan Cane as an external protecting cover to the conducting wire and insulating medium, desires to employ a material which has not hitherto been used for deep-sea cables; he has been guided in the choice of cane by its being a fibrous substance, having great flexibility, lightness, strength, and durability when submerged. The cane has long been used by the Chinese and Malays for cables as applied to anchors, and for making fast their junks to the banks of the great rivers and canals through-

out China; and the testimony of officers in the Royal Navy, and merchants of great eminence, who have resided for many years in that country, corroborate this fact; and the ocean animalculæ are not known to touch or destroy it.

The natural silicated rind has been submitted to great hydraulic pressure, and is found to be impermeable to the passage of water into the interior fibre, and, like all other woody substances when long submerged, as in the case of the timbers of a vessel that has foundered at sea, becomes eventually petrified and indestructible. The cane itself neither possesses resinous, oleaginous, nor saccharine matter; consequently, no destructive chemical change is effected by submersion.

The cane can be obtained in inexhaustible quantities in Lower Bengal, Ceylon, Singapore, and China, in lengths of fifty feet and upwards, of an uniform gauge when properly selected, and at a price so moderate as to render this cable the cheapest that can be constructed, according to the statement of the inventor.

Cane is susceptible of many combinations, either with or without wire, laid on in a spiral form, and is prevented from kinking by using strands, either of wire, hemp, or cane, laid on at right angles to the length.

The joints under test are as strong as the cane itself, and arranged to fall at intervals so as to break joint.

In paying out the cable, very slight machinery appears to be required; and instead of its descending perpendicularly from the ship's side, it will submerge in an even or horizontal position, having sufficient weight to overcome flotation, and cause it to gravitate gradually to the bottom of the ocean.

The Ratan cane, as a non-conductor, will not generate heat in the hold of the vessel, thus keeping the insulating medium at all times cool and equal, and allowing the tests to be carried on with greater certainty. The advantages, therefore, of this cable may be summed up thus:—

1st. Its great flexibility, without elasticity or compressibility.

2d. In not being affected by heat or moisture.

3d. Its being imperishable in sea water.

4th. Its strength and perfect protection to the insulating medium. All such media being too tender to be exposed as outer coverings, from certain risk of puncture, abrasion, shifting from vessel to vessel, pressure on lower sheaves of the cable when coiled in the hold from the superincumbent weight, and injury from overheating.

5th. The silicated rind, having a complete natural security against the attacks of animalculæ.

6th. Its pliability in coiling, facility in paying out, and submerging in an even or horizontal line without kinking.

7th. The buoyancy and resilient properties of the cane rendering it less susceptible to friction and abrasion.

Finally, the inventor states that it can be manufactured at a price one-third less than any other cable.

The following are stated to be the results of tests which have been applied to this cable:—

The cable when covered with cane alone—weight, $\frac{3}{4}$ ton. Breaking strain, $2\frac{1}{2}$ to 3 tons.

When combined with steel wire—weight not exceeding $1\frac{1}{4}$ ton. Breaking strain, from 4 to 5 tons.

When constructed in this latter manner, the sinking or dead weight of the steel wire is compensated for by the floating power of the cane, and the cable would descend in a horizontal position to the ocean bed slowly and without strain, and capable of spanning any sub-oceanic valley three or four miles in width, without risk of breaking.

Diameter, in every instance, within an inch.

Method of Preserving Fruit Trees from Frost.

In the month of February, while the ground is still frozen, a rather thick coat of cold manure is spread around the roots of the trees. This is allowed to remain until all danger of frost is past. It prevents the thawing of the ground and checks the budding of the trees, but so soon as the manure is removed they bud and flower rapidly.—*Dingler's Polytechnisches Journal.*

Desulphuration of Iron in Puddling.

Prof. Richter, of Leoben, Styria, recommends the oxide of lead (litharge) for this purpose; and in an experiment in which 4 lbs of litharge were added to 865 lbs. of iron, 4 lbs. of sulphuret, and $\frac{3}{4}$ lb. of phosphuret of iron, the results were wholly satisfactory, the iron being entirely soft and malleable. The operation was moreover finished in much less then the ordinary time.—*Dingler's Polytechnisches Journal.*

For the Journal of the Franklin Institute.

Stability of Vessels in Water. By John W. Nystrom.

This subject is discussed in almost every work on ship-building, but in most cases so complicated that it requires a scientific man to understand it. I have frequently been consulted on the subject, and considering its great importance in the new era of naval architecture, have written this article, which I have endeavored to make as simple and practical as possible. I will not here enter into any proofs of the formulas, which would render the article too long and tedious, but will only give the conclusive substance which bears directly on practice.

In constructing iron-clad vessels, it is difficult to bring down the centre of gravity low enough to make a good sea-going vessel, where the momentum of stability must be in a safe proportion to its sailing momentum.

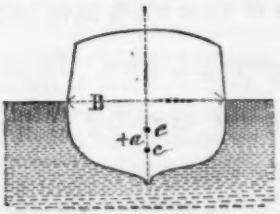
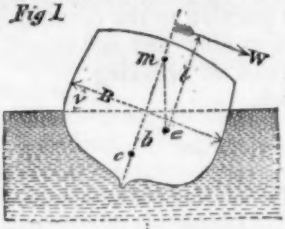


Fig 1.

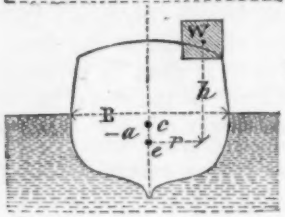
$$b = \frac{\text{D B}^3 \tan. v}{772^* \text{ L } \Delta^2} \quad . \quad . \quad . \quad . \quad . \quad 1.$$

$$\text{W } l = \text{D } (b \pm a \sin. v). \quad . \quad . \quad . \quad 2.$$



Metacentre $m = b \cot. v.$ . . 3.

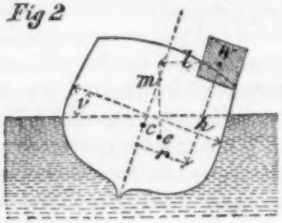
Depth $\delta = d \cos. \frac{1}{2} v.$ . . . 4.



$$\pm a = \frac{1}{\sin. v}\left(\frac{\text{W } l}{\text{D}} - b\right). \quad . \quad . \quad 5.$$

$$l = \sin. v\,(h - r \sin. v) + r \sec. v + b. \quad 6.$$

Fig 2



$$\cot. v = \frac{\text{D}}{\text{W } l}\left(\frac{\text{D B}^3}{772^* \text{ L } \Delta^2} \pm a\right). \quad . \quad 7.$$

Capsizes when $a \sin. v =$ or $> b.$. 8.

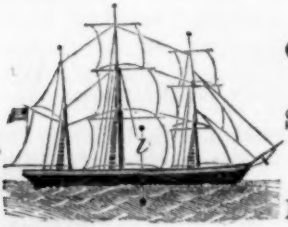
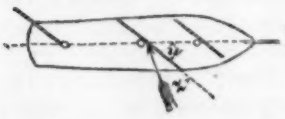


Fig 3

Careen force $\text{W} = f \text{ A} \sin. z \cos. u.$. 9.

Sailing force $\text{F} = f \text{ A} \sin. z \sin. u.$. 10.

Miles per hour $\text{M} = \sqrt{\frac{\text{F}}{6\ \Delta}}.$ . . 11.



Force of wind $f = \frac{4\ \Delta\ \text{M}^2}{\text{A} \sin. z \sin. u}.$. 12.

* 772 for salt and 750 for fresh water.

Definition of Letters.

D = displacement of the vessel in pounds.

$\mathfrak{N}$ = greatest immersed section in square feet.

B = breadth of beam in feet in the water-line.

L = length of the vessel in feet in the water-line.

a = the vertical distance in feet between the centres of gravity of the vessel and displacement when in equilibrium. When the centre of gravity of the vessel c is below that of the displacement e, as in fig. 1, then a is positive, or $+a$; and when c is above e, as in fig. 2, a is negative, or $-a$.

b = horizontal distance in feet from the centre of gravity of the displacement when in equilibrium to the same centre when out of equilibrium.

c = centre of gravity of the vessel.

e = " " displacement.

d = depth of the centre of gravity of the displacement under water-line in feet when in equilibrium, and

δ = depth of the same centre when out of equilibrium.

f = force of wind in pounds per square inch. (See Nystrom's Pocket Book, page 233.)

h = vertical height in feet from the centre of gravity of the displacement to the centre of the weight W, fig. 2, when the vessel is in equilibrium.

r = horizontal distance in feet from the centre of the vessel to the centre of the weight W, fig. 2.

l = leverage in feet, upon which any force acts to careen the vessel, to be calculated from the centre of gravity of the displacement, perpendicular to the direction of the careening force. In sailing, l is taken from the centre of gravity of the displacement to the centre of effort of the sails.

m = vertical distance in feet from the centre of gravity of the displacement when out of equilibrium to the metacentre m.

v = careen angle of the vessel.

u = angle of the sails to the length of the vessel.

z = angle of the wind to the sails.

$\mathfrak{N}$ = area of resistance of the vessel in square feet. (See Nystrom's Pocket Book, page 233.)

A = area of all the sails in square feet.

M = miles or knots per hour, by sailing.

F = force in pounds acting to propel the vessel forward.

W = any weight or force in pounds acting on the lever l, to careen the vessel.

EXAMPLE 1. The U. S. steam frigate *Niagara* is L = 329 feet long, B = 55 feet wide; greatest immersed section, $\mathfrak{N} = 855$ square feet; displacement, D = 11,200,000 pounds; vertical distance between the centres of gravity of displacement and vessel assumed to be $-a = 2{\cdot}5$ feet. What momentum (W l = ?) is required to careen her to an angle of $v = 8°$, and what force (W = ?) is required on a lever of $l = 35$ feet?

Formula 1. $$b = \frac{11{,}200{,}000 \times 55^3 \times \tan.\ 8°}{772 \times 329 \times 855^2} = 1{\cdot}414 \text{ feet.}$$

The required careen momentum will be

Formula 2. W $l = 11{,}200{,}000\ (1{\cdot}414 - 2{\cdot}5 \sin.\ 8°) = 11{,}940{,}320$ foot pounds, and the

$$\text{Force } W = \frac{11{,}940{,}320}{35} = 341{,}152 \text{ pounds} = 152 \text{ tons.}$$

EXAMPLE 2. It is required to find the momentum of stability of a man-of-war, by moving a number of guns of known weight from one side to the other. Each gun weighs 25,000 pounds, and four guns are moved to the opposite side, to $r = 20$ feet from the centre of the vessel; the height of the centre of gravity of the guns above the centre of gravity of displacement is $h = 16$ feet. There will be eight guns of 25,000 pounds, or W = 200,000 pounds careen weight on one side, by which the vessel is careened to an angle of $v = 7° 20'$. Dimensions of the vessel are D = 6,150,000 pounds, B = 40 feet, L = 260 feet, and $\mathfrak{N} = 566$ square feet. Required the vertical distance between the centres of gravity of the vessel and displacement, a = ?

Formula 1. $$b = \frac{6{,}150{,}000 \times 40^3 \times \tan.\ 7° 20'}{772 \times 260 \times 566^2} = 0{\cdot}788 \text{ feet.}$$

Formula 6. $$l = \sin.\ 7° 20' (16 - 20 \times \sin.\ 7° 20') + 20 \sec.\ 7° 20' + 0{\cdot}788 = 22{\cdot}666 \text{ feet.}$$

Formula 5. $$\pm a = \frac{1}{\sin.\ 7° 20'} \left(\frac{200{,}000 \times 22{\cdot}666}{6{,}150{,}000} - 0{\cdot}788 \right) = -0{\cdot}698 \text{ feet.}$$

a is negative when $\frac{W\ l}{D} < b$.

EXAMPLE 3. A sailing vessel of D = 1,792,000 pounds, $\mathfrak{N} = 245$ square feet, B = 27 feet, L = 175 feet, area of resistance $\mathfrak{N} = 27{\cdot}4$ square feet, (see Nystrom's Pocket Book, page 233,) area of all the sails A = 6100 square feet, centre of effort of the sails above the centre of gravity of displacement $l = 36$ feet, $a = -1{\cdot}25$ feet, angle of sails to the vessel $u = 35°$, angle of wind to the sails $z = 40°$. Required the careen angle v = ? and sailing speed M = ? in a high wind of $f = 9$ pounds per square foot.

Formula 9. $w = 9 \times 6100 \times \text{sin. } 40° \times \text{cos. } 35° = 28840$ pounds.

Formula 7. $\text{cot. } v = \dfrac{1792000}{28840 \times 36}\left(\dfrac{1792000 \times 27^3}{772 \times 175 \times 245^2} - 1{\cdot}25\right)$

$= 5{\cdot}37 = \text{cot. } 10° 30'$ the angle required.

The sailing force will be

Formula 10. $F = 9 \times 6100 \times \text{sin. } 40° \times \text{sin. } 35° = 20170$ pounds.

From which the sailing speed will be

Formula 11. $M = \sqrt{\dfrac{20170}{6 \times 27{\cdot}4}} = 11$ knots per hour.

Compressed Coal.

From the Lond. Mining Journal, No. 1352.

The value and importance of an invention which can profitably utilize that great proportion of this our great staple product that is now entirely lost, was fully adverted to in last week's Journal. It was there shown, upon the authority of Mr. Alex. Bassett, that 40 per cent. at least was never even brought to surface, as, according to present arrangements, it would not pay for raising. The question of the compression of coal has engaged the attention of mechanical and scientific men for many years, the great difficulty having been to bring about the desired result without the admixture of extraneous cohesive matter. By the amalgamation of several inventions, the patent rights of which have been purchased by the company now before the public, this coveted goal appears to have been reached, it being stated that the smallest coal can be compressed into blocks which occupy one-third the space of ordinary coal, taking but 31 cubic feet to the ton, while raw coal averages from 44 to 48 feet. The process by which these compressed blocks are obtained is inexpensive, and without complication. In the first place, the pure coal-dust, or slack, is conveyed through a washing machine, for the purpose of disconnecting it from any stony particles it may contain. It is then subjected to a steady heat, until its bitumenous parts are rendered quite soft, after which it is passed into a moulding machine. This comprises a rotary table containing the moulds, around which are situated three presses—namely, the feeder, for filling the moulds; the main press for condensing the block; and the discharger, which removes the block out of the mould, whence it falls into a traveling web, which carries it away. The presses act simultaneously, and between each stroke the table makes one-third of a revolution, by which the coal is removed from one press to the other. An apparatus is provided for extracting the gases from the coal during pressure, ingeniously opening out the air-passages at each stroke, which would otherwise become choked by the bitumen. In these presses, necessarily of a very powerful description, breakages would be always occurring, but for a provision which has been made by the fulcrum of the levers of the main press resting on the ram of a hydraulic press, the safety-valve of which is loaded only to the ex-

tent that the strength of the machine will bear. Each machine, which is inexpensive in construction, is capable, it is calculated, of making 28 tons per day, at an estimated cost of 2*s.* per ton. From having during the process of washing the stony parts removed, and from the lighter gases which produce smoke being driven off during the manufacture, it is said that steam vessels provided with these blocks of compressed coal will carry fuel for steaming nearly double the number of days; and, moreover, that this fuel is free from the danger of spontaneous combustion. For domestic and manufacturing purposes it is cheaper and cleaner than raw coal. We understand that the company has met with a most favorable reception from the public, and that active operations will forthwith be commenced.

Gigantic Iron Casting.

From the Lond. Mechanics' Magazine, January, 1862.

In noting, says the *Liverpool Albion*, the iron-work capabilities of Liverpool, we have on several occasions been led to refer to the ease and success with which the most Titanic kinds of iron-work can be accomplished in the leading establishments of the town, and it affords us pleasure to mark and chronicle from time to time the practical illustration of such skill and power. A notable and gratifying instance of this was afforded to us on Friday afternoon, at the well-appointed and extensive foundry and engineering works of Messrs. Fawcett, Preston & Co. This was the casting of a huge fabric of iron, intended as the sole or anvil-block of a gigantic steam hammer, about to be erected on the premises of the Mersey Steel and Iron Works. Some idea of the magnitude of this casting may be formed from the statement that it was a somewhat irregular mass of metal measuring nine feet square on the base, which is twelve inches thick. From the middle of this base there rises a vertical projection five feet high, seven feet wide from side to side, and twenty inches thick. This, which forms the bed of a steel anvil, is supported by four diagonally-shaped ribs, tapering from the base to the top of the vertical ridge; these ribs being each twelve inches thick. Midway between the ribs, there are two blocks, one on each side of the vertical ridge, and connected with it, each measuring two feet high by two feet six inches wide. The whole of this irregular series of concentric cubes form, it must be remembered, one homogeneous mass of metal of the enormous weight of between thirty-five and thirty-eight tons. To complete this stupendous casting, no less than forty tons of metal were melted; yet such are the comprehensive and efficient means of operation possessed by Messrs. Fawcett, Preston & Co., that the whole of this immense weight of metal was fused and run without any addition to their ordinary appliances or staff of operatives. The casting, which was in every respect most successful, was witnessed by a large assemblage of ladies and gentlemen, the scene being at once impressive and interesting. In a semicircle were arranged a large number of curiously

anxious spectators, while the central space was occupied by huge cranes, worked with energetic activity by stalwart men, whose swart brows formed a striking contrast to the inquiring and half alarmed visages of the on-lookers, as they gleamed in the fiery radiance of the cataracts of molten iron which spouted from the seemingly volcanic mouths of two vast air furnaces, or received a conflicting glare from huge tubs of liquid metal gathered from the outlets to two blast cupola furnaces, as their contents were added in supplementary libations to the raging streams of glowing metal weltering through the portals which lead to the deeply buried mould. Variety was given to this impressive scene by rapid and numerous corruscations of stellar particles shot off from the fiery mass, and forming a pyrotechnic display of unusual brilliancy. The whole of the perilous-looking process of casting was completed in less than a quarter of an hour from the opening of the furnaces, and, happily, without the slightest accident.

On the Employment of Galvanized Iron for Armor-plated Ships.

By Dr. Calvert.

From the Lond. Mechanics' Magazine, April, 1862.

The author stated that no doubt many gentlemen present were acquainted with the fact that he had been for some time past engaged in ascertaining the chemical composition of various woods employed and susceptible of being employed in the navy. On a recent visit to one of the dockyards, he found that, while the armor-plates were fixed against a layer of teak, the ribs of the ship were of oak, and that the iron bolts which were to fasten the plates were to pass through the oak ribs. It occurred to him that the inconvenience which would probably result from the action of the oak upon the iron might be obviated by substituting galvanized iron bolts for those now in use, and he therefore instituted a series of experiments, the results of which he had great pleasure in laying before the meeting.

The first series of experiments consisted in having driven through large pieces of oak, bolts and screws of iron and galvanized iron prepared by his friends, Messrs. Richard Johnson and Brother, of Dale Street, Manchester, which were then immersed in soft and sea water for the last three months. The results clearly showed, first, that the friction did not remove the zinc from the galvanized iron; secondly, that the oak and galvanized bolts were unchanged; whilst in the case of the iron bolts, they were much rusted, and the pieces of oak had become quite black by the formation of tannate and gallate of peroxide of iron. During the experiments, the waters were changed every week, and those containing the galvanized iron appeared unchanged, whilst in the case of the iron, they had a dark blue-black appearance, owing to the formation of gallate and tannate of iron.

In order to ascertain the comparative action of soft and salt water

upon iron and galvanized iron when in contact with oak under identical circumstances, he made the following series of experiments.

Plates of galvanized iron, having 18 inches of surface lost, during three months, the following weights:—

	Soft water.	Sea water.
Plate No. 1,	0·10 grains.	——
" No. 2,	0·11 "	——
" No. 3,		0·095 grains.
" No. 4,		0·090 "

Similar plates of iron lost during the same time:—

	Soft water.	Sea water.
Plate No. 1,	1·23 grains.	——
" No. 2,	1·52 "	——
" No. 3,		2·40 grains.
" No. 4,		2 38 "

There can, therefore, be no doubt that galvanized iron offers great advantages, the action of water on it being less than a tenth of the same action on ordinary iron. As there is no doubt that iron when galvanized is in the most favorable electrical condition to resist the action of oxygen, being in an electro-negative condition, it follows that, in all probability, the use of galvanized iron would be very advantageous in armor-plated and other iron ships. The author hoped that government, and other large ship-builders, would avail themselves of this suggestion, and make experiments on a large scale to verify the results he had obtained.

The Salting of Brick-work. By Jos. A. Davies.

From the London Builder, No. 917.

The question was, I think, asked some time since in your paper, whether any means could be adopted to prevent the salting of brick-work. In a building to which I was architect last year, we tried, by the advice of a chemist, oiling the facing bricks with linseed oil. The oil was applied with a brush to one face and one end of each brick; and, as no salting has appeared on any part of the brick-work, which was finished about twelve months ago, the experiment seems to have been in this case successful.

I have found the same kind of facing-bricks become salted considerably where they have been used without oiling; and, from the appearance of the mortar joints in the case in question, think that the same would have occurred in the present instance, had the oiling not been adopted.

The salting of brick-work is so detrimental to its appearance, that any means of preventing it is of value; and I therefore send you the result of my own experience on the subject. The oiling rather improves than otherwise the color of the brick.

For the Journal of the Franklin Institute.

Decision of the U. S. Patent Office on an Application for the Extension of the Patent granted to H. A. Wells for Improvements in Forming and Hardening Hat Bodies. Reported by H. Howson, Esq., Philadelphia.

On the application of Eliza Wells, administratrix of the estate of Henry A. Wells, deceased, for the extension of letters patent granted to said Wells on the 25th day of April, 1846, re-issued in two patents dated respectively September 30th and October 7th, 1856, for improvements in forming and hardening hat bodies, the hearing was set for the 16th of April, 1860. In this case, the Examiner to whom the application and other papers were referred, has reported that the invention was novel and patentable when patented; and this, as well as its value and importance to the public, the inadequacy of the remuneration received by the inventor for his time, ingenuity, and expense in originating and perfecting the invention, and his diligence in introducing it into general use, are not denied or questioned by the party who objects to the grant of the extension. At all events, the testimony on these points is full and clear, and establishes to my entire satisfaction that the invention has resulted, thus far, since its introduction into use, in a saving to the public of not less than six and not far from twelve millions of dollars, while the entire receipts of the inventor from all sources connected with the patent have been more than absorbed in the unavoidable expenses of the invention, in the costs of procuring the patent, in fees paid for necessary litigation, and in the economical support of his family, leaving him, at the period when he was compelled to part with all his interest in the patent, not only unremunerated, but absolutely and hopelessly insolvent. Such, I am warranted by the testimony in asserting, was the condition of a man whose mechanical genius had enabled him, after years of toil and privation, to perfect an invention for the manufacture of an indispensable article of consumption which has, within less than fourteen years, reduced its cost to the community by the sum of twelve millions of dollars.

That man lived and died a pauper, and but for the bounty of those who finally became possessed of all his rights under the patent, his representatives, for whose benefit this extension is sought, would have found themselves, at his death, homeless and houseless dependents upon the charity of the world. In the above statement there is no exaggeration; it is a plain and truthful narrative of facts supported by unimpeachable testimony, uncontroverted, indeed admitted, by the remonstrant himself, for his opposition is made to rest solely upon a legal proposition, affecting the right of the applicant to receive and of this office to grant an extension of the patent under the circumstances of this case. The circumstances referred to may be stated as follows: On the 25th day of April, 1846, letters patent of the United States were granted to Henry A. Wells, now deceased, for improvements in

the process and machinery for the manufacture of fur hat bodies. At several periods of time and in different proportions, the entire interest of the inventor in this patent passed by assignments to Charles St. John, Henry A. Burr, Albert H. Wright, and James M. Riblet, by whom it was subsequently surrendered for re-issue. In the re-issue, under the 5th section of the Patent Act of the 3d of March, 1837, the patent was divided, and two patents were issued—one, dated on the 30th day of September, 1856, for the machine for forming the bats; the other, dated on the 7th day of October, 1856, for the process of hardening and removing the bats from the cone. Each of these patents was issued in the names of Charles St. John, Henry A. Burr, Albert H. Wright, and James M. Riblet, as assignees, and both were granted for the unexpired term of fourteen years from the 25th day of April, 1846, the date of the original patent. Henry A. Wells, the inventor and original patentee, has departed this life, and Eliza Wells, the administratrix of his estate, has accepted the re-issued patents granted to the assignees as a proper amendment of the original patent, and now makes application for an extension. In this state of the case it is contended that the original letters patent granted to Wells having been surrendered and cancelled, no extension thereof can be allowed to his administratrix for the benefit of his representatives; nor can an extension of the re-issued patents be granted either to the administratrix of Wells, or to the patentees therein named; not to the former, because Wells is not the patentee of those patents, nor to the latter, because they are assignees, and are so named and described in the patents themselves. In short, the proposition submitted by the remonstrant, and sought to be established in his argument, is, that an extension of a patent can only be granted to the party named and described therein as patentee. It can scarcely be considered necessary, at this day, to enter upon a line of argument for the purpose of demonstrating that the true intent of the 18th section of the Act approved July 4, 1836, entitled "An Act to promote the progress of useful arts, and to repeal all acts and parts of acts heretofore made for that purpose," was to secure the inventor an adequate reward for the time, ingenuity, and expense bestowed upon his invention, and upon its introduction into use; and that, in authorizing upon certain conditions, the extension of his patent for an additional period of seven years, it was clearly intended to afford to the inventor, and to him alone, an opportunity to obtain an amount of reasonable remuneration, which, without fault on his part, he had failed to receive during the term for which the original patent was granted. That the term "patentee," as used in the 18th section of the Act of 1836, is synonymous with and equivalent to the term "inventor," and that the right to an extension of a patent was and is vested by that section, solely and alone in the author of the invention, and not in the assignees in whose names the patent may have issued, is now too well settled, both in the practice of this office and by decisions of the highest judicial tribunals of the country, to admit of question or doubt.

That the Act of 1836 authorizes the grant of an extended term of a patent to the executor or administrator of the inventor in trust for the heirs at law, or devisees, as well as to the patentee himself, is equally well settled, and had the application in this case rested upon an original outstanding patent in the name of the inventor or of the assignee of his interest therein, no difficulty whatever would have been experienced in granting the extension. (See Woodworth *vs.* Sherman, 3 Story, 171; Willson *vs.* Rousseau, 4 Howard, 674-5.)

The case of John Thomas, cited by the remonstrant, cannot be accepted as authority against this position, for although, from the very meagre report of that decision, it appears that the Board of Extension rejected his application for the reason that "the applicant having assigned all right, title, and interest in the invention before the letters patent issued, was not the patentee, and consequently was not entitled to the benefit of the Act;" the facts likewise show that he had not only assigned his right under the patent before it issued, but had also disposed, absolutely, of all contingent interest in its future extension; and it is by no means improbable that this latter circumstance, coupled with a palpable attempt, on his part, to perpetrate a fraud upon the assignees, influenced, materially, the decision of the Board. Be that as it may, the doctrine of that case as well as the case of the Hansons, also cited by the remonstrant, was subsequently, and I think properly, overruled by Commissioner Hodges in the case of Goodyear and Hayward, and has not since been regarded as the law of this office. The only question remaining to be considered is, whether or not the surrender of the original patent by the assignees, and the subsequent re-issues in their names, operate to divest the representatives of Wells of the right to obtain an extension which, otherwise, they would clearly have possessed. It is not pretended that the assignments in this case transferred, either expressly or by implication, any interest whatever beyond the life of the existing patent. Hence it would seem to follow that the rights acquired by the assignees were necessarily limited to the term of fourteen years from the date of the grant and terminated at the expiration of that period, leaving any remaining interest of a contingent character to be rendered certain and to become reinvested in the original patentee by operation of law and by the action of the Patent Office in the extension of the patent. This view is fully sustained by the Supreme Court in the case of Willson *vs.* Rousseau, where it is said that "all the rights of assignees or grantees, whether in a share of the patent or to a specified portion of the territory held under it, terminate at the end of fourteen years, and become reinvested in the patentee under the new grant." Can the assignee, by a surrender of the patent for the purpose of re-issue, or by any other act of his, without the consent of the inventor, divest him of rights thus secured by law? Justice Story, in Woodworth *et alias vs.* Stone (3 Story, 749) says: "It is not in the power of the patentee by a surrender of his patent, to affect the rights of third persons to whom he had previously passed his interest in the whole or a

part of the patent, without their consent." If this be sound law, as it undoubtedly is, then the converse of the proposition must hold good, and equal protection be afforded to the patentee against injurious acts of his assignees; for that might well be considered an arbitrary and unjust rule of law which, while it furnishes the most ample protection to the assignee against the effects of acts done by his assignor in prejudice of his rights, at the same time leaves it in the power of the former to dispose absolutely of the interests of the latter, over which he possessed no legal control by assignment or otherwise, and that too without his acquiescence or consent. The objection on this point, however, appears to me to proceed upon an entire misconception as to the object and effect of a surrender and re-issue of a patent. It assumes that the surrender of the original patent and the re-issue of one or more patents in its stead operate to divest all parties, whether patentees or assignees, of a right to claim protection under it. This view is, certainly, erroneous. The 13th section of the Patent Act of 1836 was intended to secure to patentees, and to their representatives and assignees, protection against the invalidity of original patents arising from defective or insufficient descriptions or specifications, and for other causes specified in the section, the result of inadvertence, accident, or mistake; and it makes it lawful for the Commissioner, upon the surrender of any such patent, and a compliance with other conditions, to cause a new patent to be issued, for the *same invention*, for the residue of the unexpired period for which the original patent was granted, in accordance with the corrected descriptions and specifications. As the re-issued patent can only be for precisely the same invention as that originally patented, the single alteration being in the descriptions and specifications, it follows that no change whatever is operated upon the rights of the inventor under the original patent so far as the question of extension is concerned. The exclusive right to the use and enjoyment of the invention is the thing extended, and that is wholly unaffected by a previous surrender of the patent by an assignee of the entire interest under it, and a re-issue in his name. Under the 7th section of the Patent Act of 1837, where the specification is too broad, the patentee or his assignee has a right to disclaim. In such case the disclaimer is "taken and considered as a part of the original specification, to *the extent* of the interest which shall be possessed in the patent, or right secured thereby, by the disclaimant and by those claiming by or under him." Thus, where there are several fractional interests held under a patent, and one party disclaims, the interests of the other parties are in no way affected thereby; the former holds under the amended, the latter under the original specifications, but both under the same patent. The effect, however, is the same as if two patents had issued, securing one claim to one person and a different claim to another person in the same invention. Now, inasmuch as the object of the re-issue, when the specification is too broad, is precisely the same as that of the disclaimer, namely, to narrow, and thereby to validate the claim, and the inventor or his assignees may

elect between the two remedies, it is difficult to discover a sufficient reason why, in the one case, the rights of third persons may be divested without their consent, while, in the other, such rights are effectually protected by express provisions of law. Such a construction of the 13th section of the Act of 1836 and the 7th section of the Act of 1837 would impute to Congress a design to place a snare at the feet of meritorious inventors, instead of affording to them the protection and encouragement enjoined by the Constitution. If the doctrine contended for in this case by the remonstrant is well founded, then there is no end to the fraud and circumvention which might be practised upon inventors, or upon innocent parties who have acquired rights under patents for full and valuable considerations paid by them. If the surrender and re-issue operated an entire extinction of all rights under the patent, then it would be in the power of a dishonest inventor to assign to a third party an interest in the invention for a full and valuable consideration, and, immediately thereafter, to surrender the patent, obtain a re-issue in his own name or in that of some other assignee, and thus deprive him of all the rights to which he became entitled by a valid and lawful assignment. The same consequences by a like process might be entailed upon the inventor by his assignee, while all other parties having rights would become the helpless victims of the same fraud. This is not the law, and as it is not in the power of an inventor who has assigned an interest in his patent, by any act of his to prejudice the rights of his assignee without his consent, so neither can an assignee of a fractional interest do any act without the consent of the inventor which will interfere with or in any manner impair the vested rights of such inventor. As, under the 7th section of the Act of 1837, a disclaimer made by one party in interest affects only the rights of the party disclaiming, leaving all others to hold under the original specification, so, also, under the 13th section of the Act of 1836, upon the surrender of a patent for re-issue by the inventor and patentee, or by an assignee, either or both being possessed of fractional interests only, all other parties not consenting thereto are unaffected thereby, and are entitled to claim under the original patent as if the same had never been surrendered. On the other hand, upon the surrender of the old, and a re-issue of the new patent, by one party in interest without the knowledge or consent of the others, the latter have the right to elect between the two patents, and if they choose to claim and hold under the re-issued patent, and of this right they cannot be deprived by the party who makes the surrender, even although the re-issued patent is in his name as patentee. This is no new doctrine. In the case of Potter and Wheeler *vs.* Holland, decided by Judge Ingersoll at the September term, 1858, of the Circuit Court of the United States for the District of Connecticut, (Justice Nelson concurring in the opinion,) this whole subject of the effect of a surrender and re-issue of a patent upon the rights of third parties in interest, was considered and discussed with great learning and ability, the Court deciding that the rights of a third person to whom a patentee had previously passed his interest in a part of a pa-

tent, would not be affected, without his consent, by the surrender of the old patent by the patentee alone, and the taking of a re-issued patent, and that after such surrender and re-issue (both the surrender and re-issue being valid) such third person has the same rights under the old patent, if he chooses not to take advantage of the surrender and the re-issue, that he had to that patent before such surrender and re-issue. And, referring to the rule laid down by Judge Story in Woodworth *et alias vs.* Stone, to the effect that it is not in the power of the patentee by a surrender of his patent, to affect the rights of third persons, to whom he had previously passed his interest in the whole or a part of the patent, without their consent, Judge Ingersoll remarked that Judge Story "must have been of the opinion that notwithstanding such surrender and re-issue, such third persons could hold under the old patent, if they should so choose, for otherwise their rights might be injuriously affected without their consent." In the course of the same opinion it was ruled, that "This consent may be manifested either by joining in the surrender with the patentee, or by previously authorizing it, or by subsequently ratifying or approving it. And taking advantage and benefit of it would be a ratification." And it is further said, that "it may be considered as a sound and settled principle, that a person to whom the patentee has passed his interest in a part of the old patent, upon the surrender of the same by the patentee, and obtaining a re-issued patent, is entitled to the same rights under the re-issued patent that he had to the old one. The patentee by taking a re-issue cannot deprive him of the same right to it that he had to the old one, if he wishes to take benefit of such right. And when he does take advantage and benefit of the re-issued patent, he consents to give up, and does give up, the right which he had under the old one." I entirely concur in the reasoning and conclusions of the Court in the case last above quoted, and they seem to me to settle, definitely, the main question now under discussion.

From the views which I have thus endeavored to enforce, the following propositions appear legitimately to follow:

1st. That the inventor and, in the event of his death, his legal representatives are the only persons contemplated by the 18th section of the Patent Act of 1836 and the 10th section of the same act: that they are the sole objects of the bounty of Congress, and that whether the patent is issued in the name of such inventor or in that of another person, he or his representatives alone are entitled, upon a compliance with the requirements of that section, to an extension of the term for which the original patent was granted.

2d. That an assignment of the entire interest in his invention vests in the assignee no rights beyond the life of the patent, and that upon the expiration of the term for which the patent is granted all the rights of assignees or grantees, whether in a share of the patent or to a specified portion of the territory held under it, terminate, and by the act of extension are reinvested in the inventor or his legal representatives.

3d. That the exclusive right to the use and enjoyment of the inven-

tion for an additional term of seven years from the termination of the original grant is the thing extended, and that the right of the inventor to such extension is wholly unaffected by a surrender of the patent and a re-issue of a new patent in the name of an assignee.

4th. That a surrender of a patent and a re-issue of a new patent do not operate to extinguish the rights acquired by third persons under the surrendered patent without their consent: but that such parties as consent to the surrender may claim under the re-issued patent, and all others not consenting thereto may, at the same time, claim and hold under the surrendered patent.

I am, therefore, of opinion that the surrender by the assignees of the original patent granted to Henry A. Wells, and the re-issue of the two patents in its stead in their names, worked no change whatever in the rights of the inventor or his representatives; and inasmuch as his administratrix has assented to the re-issues and accepted the same, and has established by competent evidence that the invention is of public utility and importance, that due diligence has been employed to introduce it into use, and that adequate remuneration has not been received, I am further of opinion that the extension, as prayed for, should be granted. PHILIP F. THOMAS, *Commissioner.*

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, June 19, 1862.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Letters were read from Hon. James E. Harvey, U. S. Minister at Lisbon, Portugal; and from the Smithsonian Institution, Washington, D. C.

Donations to the Library were received from the Royal Society, and the Chemical Society, London; Prof. A. D. Bache, U. S. Coast Survey, Hon. A. A. Sargent, U. S. Congress, and Hon. Wm. D. Kelley, U. S. Congress, Washington, D. C.; the Mercantile Library Association, Brooklyn, N. Y.; Dr. Chas. M. Wetherill, Lafayette, Ind.; Thos. C. Clark, Esq., Camden, N. J.; G. R. Smith, Esq., Penna. Senate, Harrisburg, Penna.; and Messrs. George M. Conarroe, Isaac B. Garrigues, John Warner, Henry Howson, Wm. B. Perkins, and Wm. J. Mullen, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of May was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (2) were proposed, and the candidate (1) proposed at the last meeting was duly elected.

Mr. Howson exhibited a patent Naphthometer, or benzine detector. This is the invention of Messrs. H. J. Smith and Woodruff Jones of this city. The instrument consists of a reservoir with a tightly fitting cover, from the top of which projects a tube, surrounding a wick tube. A thermometer also passes through the cover, and occupies such a position that its bulb comes within a short distance from the bottom of the reservoir. In order to determine the temperature at which the oil gives off sufficient vapor to cause an explosion, the oil to be tested is poured into the reservoir, the wick is lighted, and the instrument placed on a stove or over the flame of a lamp. At a temperature which varies in proportion to the quantity of explosive ingredients contained in the oil, the vapor is given off, and mixing with the air in the reservoir, passes up through the space between the wick tube and the larger tube, and explodes when ignited by the flame, thereby extinguishing the light. The height of the mercury in the thermometer will determine the quality of the oil.

The contrivance is very simple and cheap, and enables any one to ascertain in a few minutes whether an oil is of a quality to be burned with safety.

A Heater to be applied to Coal Oil Lamps was also exhibited by Mr. Howson. This instrument, the invention of Mr. Woodruff Jones, is intended to be used in sick chambers for heating articles of diet, &c. It consists of a metal cylinder or casing, the upper edge of which is provided with a ring, and the lower with a flanch adapted to the burner of a coal oil lamp, so that the heat of the flame may be communicated to articles of food, &c., contained in a vessel resting on the ring.

Mr. H. then explained Mr. Cooley's patent mode of Discharging Projectiles. The shot or shell has an orifice into which fits a solid cylinder, and between the end of the latter and the end of the recess intervenes the charge of powder. The cylinder is surrounded with a shield which prevents the products of the ignition from injuring the gunners.

Mr. Howson also exhibited a cavalry sword and several varieties of tools with the Gum Elastic Handles, patented by M. C. Bogia, Esq. These handles have been highly approved of as presenting a slightly yielding surface, and one which affords the means of maintaining a firm grip in the hand. It is appliable to all descriptions of tools.

A. F. Ward exhibited charts, and explained his system of Semaphoric Color Signals. This system has been brought to a high state of perfection by Mr. W., and has been recommended to Congress by the Board of Trade of this city.

Mr. John W. Nystrom exhibited some specimens of angle-iron and keel-gutter, made by him at General Maltsoff's establishment in Russia, and made the following remarks :

This form of angle-iron is best adapted for frames and beams in river steamers of light draft. The dimensions of one of the specimens shown is $1\frac{7}{8} \times \frac{5}{16} + 2\frac{7}{8} \times \frac{3}{16}$ inches, weighing 4·125 lbs. per foot; and of the other, $2\frac{1}{2} \times \frac{3}{8} + 4 \times \frac{1}{4}$ inches, weighing 5·47 lbs. per foot. The improvements in this angle-iron consists,

First, in a bead on the one edge, which makes it stronger and about 20 per cent. lighter than ordinary angle-iron. Experiments on its strength were made in Russia, but the results have been lost. The bead is placed on the inside of the angle-iron, so as to make the frame lie flat on the cast iron form when bending it.

Secondly, the countersunk holes rolled in the angle-iron, as shown in the sample. In the ordinary iron ship-building practice, the angle-iron is generally bent into the shape of the frames, after which the holes are drilled in. If the holes are punched first, the angle-iron does not bend so well, and the holes will get out of shape in sharp curves. When the angle-iron is bent, the holes cannot be punched, because the punching would throw it out of shape. Now, rolling the countersink, leaving a thickness of about $\frac{1}{8}$th of an inch, allows the angle-iron to be bent into shape, after which, the balance of the holes are punched out by a hand-press without altering the shape of the frame.

In Russia, I had it so arranged that the angle-iron was taken direct from the rolling-mill, bent and beveled to the true shape of the frame in the one original heat, as fast as the angle-iron could be rolled. The deck-beams were made of similar sections to the frames, but of larger size, and bent into shape in the original rolling heat.

The third sample here exhibited is the form of the keel of the steamers which I built in Russia. It is in the form of a U, with rolled countersinks. We called it the keel-gutter, because it is used for that purpose in conveying the bilge-water to the pumps.

Except for balloon navigation, there is no case where combined strength and lightness require such careful consideration as in light draft river steamers, where an inch or two more draft of water may render navigation impossible.

One river steamer, the *Astracan*, which I built for the river Volga, was of the following dimensions:—

Length in water-line, . . .	234 feet.
Breadth of beam, . . .	22 "
Engines, oscillating.	Two cylinders, 54 by 54 inches.

To carry 400 passengers and 32 tons freight, including 8 tons for passengers' baggage; with fuel on board for six hours at a speed of 20 to 25 versts per hour, the steamer drew only 3 feet 4 inches of water.

The angle-iron in that steamer amounted to 9000 feet, which, with 20 per cent. difference in weight, will be about 8000 lbs., or about 50 passengers, or about 2 inches in draft of water.

I have here a drawing of the steamer *Astracan*, which I believe contains many improvements in strength and lightness. Should the members wish to examine it at the conclusion of the meeting, I shall be glad to give any explanation requested.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

MAY.—The month of May, 1862, was warmer than usual. The mean temperature was nearly 4° higher than that of May, 1861.

The warmest day of the month was the 23d, of which the mean temperature was 75·8°. The maximum temperature for the month (85°) occurred on the same day.

The 1st was the coldest day of the month, having a mean temperature of 50·5°. The minimum (40°) was reached on the 8th.

The range of the thermometer for the month was 45°.

The greatest change of temperature in the course of a day was 32°, on the 9th of the month; the least was 10°, on the 27th. The average daily oscillation of temperature (19·81°) was a little greater than that for May, 1861, and about 1½° greater than the average for the month for eleven years.

The greatest mean daily range of temperature was 17·2°, between the 23d and 24th days of the month; the least was 1°, between the 4th and 5th. The average daily range for the month (5·77°) was about a quarter of a degree greater than usual.

The greatest pressure of the atmosphere (30·058 inches) occurred on the morning of the 12th of the month; the least (29·518 inches) on the 19th. The mean pressure for a day was greatest (30·007 inches) on the 12th, and least (29·553 inches) on the 19th. The average pressure for the month (29·762 inches) was about four-hundredths of an inch greater than in May, 1861, and about the same amount less than the average pressure for the month for eleven years.

The greatest mean daily range of atmospheric pressure was 0·324 of an inch, and occurred between the 12th and 13th days of the month; the least was 0·035 of an inch, between the 24th and 25th. The average mean daily range for the month (0·124 inch) was identical with that for eleven years, but was three-hundredths of an inch less than that for May, 1861.

The force of vapor was greater than for May of last year, but was still less than the average for the month. It was greatest (0·594 in.) on the afternoon of the 21st, and least (0·105 in.) on the afternoon of the 8th of the month. The average for the month (0·326 in.) was about four-hundredths of an inch less than the average for May for eleven years.

The relative humidity was greater in the morning and less in the

evening than for May, 1861, but the general average for the month as well as for 2 P. M. was almost identical with that for last year. It was, however, about seven per cent. below the general average for eleven years. It was greatest (93 per cent.) during a rain storm on the morning of the 27th of the month, and least (18 per cent.) on the afternoon of the 8th.

Rain fell on nine days, to the aggregate depth of 2·083 inches, which is more than four inches less than fell in May, 1861, and over two inches less than the average for the month for eleven years. The number of rainy days was less than for any May during the last eleven years, except in the year 1855, when rain fell on but eight days. The quantity of rain was also less than for May during the same period, except in 1859, when but 1·946 inches fell.

There was not one day of the month entirely free from clouds at the hours of observation, and there were but three days, the 1st, 27th, and 30th, on which the sky was completely covered with clouds at those hours. The average amount of the sky covered with clouds during the month is given in the following table of comparisons:

A Comparison of some of the Meteorological Phenomena of MAY, 1862, *with those of* MAY, 1861, *and of the same month for* ELEVEN *years, at Philadelphia, Pa.*
Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich.

	May, 1862.	May, 1861.	May, 11 Years.
Thermometer.—Highest,	85°	83°	90°
" Lowest,	40	36	35
" Mean daily oscillation,	19·81	19·55	17·12
" " daily range,	5·77	5·06	5·55
" Means at 7 A. M.,	57·85	55·40	58·14
" " 2 P. M.,	70·08	65·74	69·45
" " 9 P. M.,	61·32	57·00	61·16
" " for the Month,	63·08	59·38	62·92
Barometer.—Highest,	30·058 in.	30·338 in.	30·338 in.
" Lowest,	29·518	29·096	29·096
" Mean daily range,	·124	·156	·124
" Means at 7 A. M.,	29·785	29·744	29·828
" " 2 P. M.,	29·740	29·691	29·792
" " 9 P. M.,	29·760	29·726	29·814
" " for the Month,	29·762	29·720	29·811
Force of Vapor.—Means at 7 A. M.,	·320 in	·282 in.	·350 in.
" " " 2 P. M.,	·324	·284	·368
" " " 9 P. M.,	·335	·297	·371
" " " for the Month,	·326	·288	·363
Relative Humidity.—Means at 7 A. M.,	64·2 per ct.	62·7 per ct.	71·2 per ct.
" " " 2 P. M.,	44·9	44·5	51·2
" " " 9 P. M.,	60·3	62·6	67·9
" " "for the Month,	56·5	56·6	63·4
Rain, amount,	2·083 in.	6·240 in.	4·226 in.
No. of days on which rain fell,	9	13	12·9
Per centum of sky covered with clouds,	54	45	55
Prevailing winds—Times in 1000-ths,	s53°37′w·136	s.72°48′w·257	s69°36′ w·117